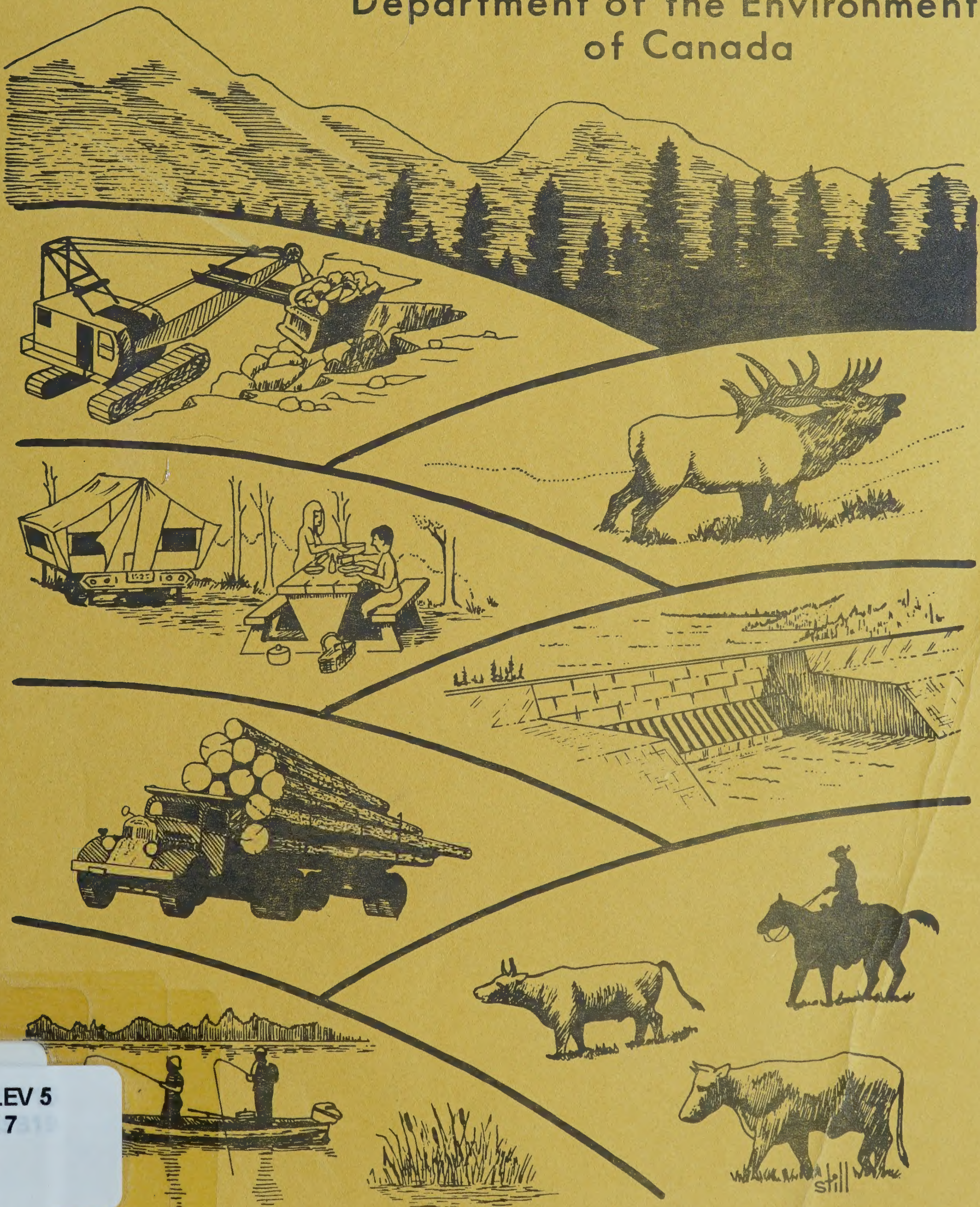
LAND USE IN THE EAST SLOPES OF ALBERTA

A brief submitted by the

Department of the Environment of Canada



LAND USE AND RESOURCE DEVELOPMENT

IN THE EAST SLOPES OF ALBERTA

BACKGROUND PAPERS TO A BRIEF

PRESENTED BY

THE DEPARTMENT OF THE ENVIRONMENT OF CANADA

TO PUBLIC HEARINGS HELD BY THE

ALBERTA ENVIRONMENT CONSERVATION AUTHORITY

JULY, 1973

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BACKGROUND PAPERS ON LAND USE AND RESOURCE DEVELOPMENT IN THE EAST SLOPES

A. INTRODUCTION

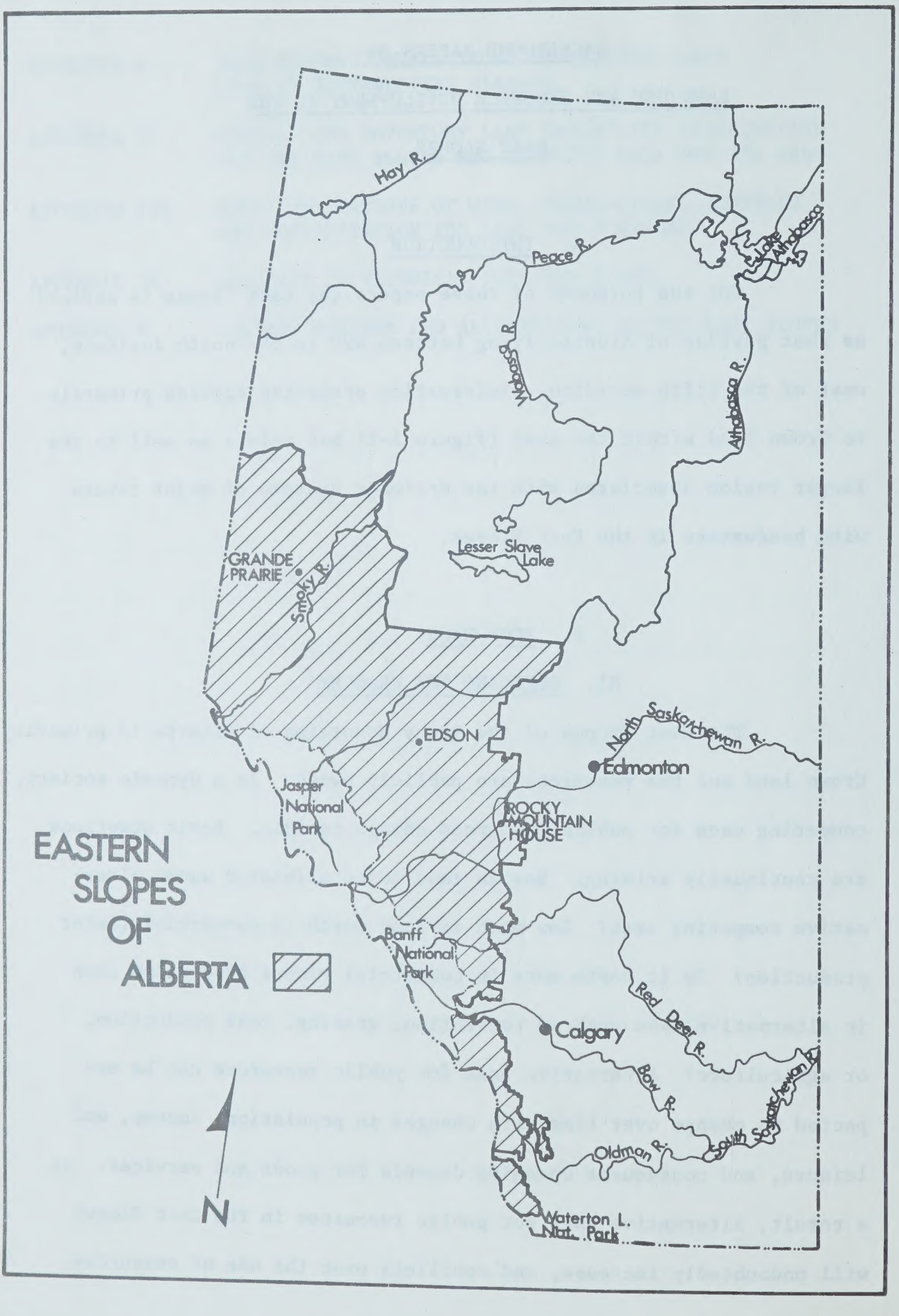
For the purposes of these papers the East Slopes is defined as that portion of Alberta lying between 49° to 55° north latitude, west of the fifth meridian. Information presented applies primarily to Crown land within the area (Figure A-1) but refers as well to the larger region associated with the drainage systems of major rivers with headwaters in the East Slopes.

B. ECONOMICS

B1. DEFINING THE PROBLEM

The East Slopes of the Rocky Mountains of Alberta is primarily Crown land and the resources are publicly owned. In a dynamic society, competing uses for public resources change rapidly. Basic questions are continually arising. How is land to be allocated among alternative competing uses? How much is land worth in commercial timber production? Is it worth more in commercial timber production than in alternative uses such as recreation, grazing, coal production, or agriculture? Alternative uses for public resources can be expected to change over time with changes in population, income, and leisure, and consequent changing demands for goods and services. As a result, alternative uses for public resources in the East Slopes will undoubtedly increase, and conflicts over the use of resources

Figure A-1


Hay R.
Peace R.
L. Athabasca
Wabasca R.
Athabasca R.
Lesser Slave Lake
GRANDE PRAIRIE
Smoky R.
EDSON
North Saskatchewan R.
Edmonton
Jasper National Park
ROCKY MOUNTAIN HOUSE
EASTERN SLOPES OF ALBERTA
Banff National Park
Red Deer R.
Calgary
Bow R.
South Saskatchewan R.
Oldman R.
Waterton L. Nat. Park
N

will intensify. There is a need for the development of "decision criteria", to be used as tools for the efficient allocation of resources among competing uses. Such criteria should be oriented to the welfare of all citizens, otherwise benefits may be transferred to individual user groups at a cost to the resource stockholders.

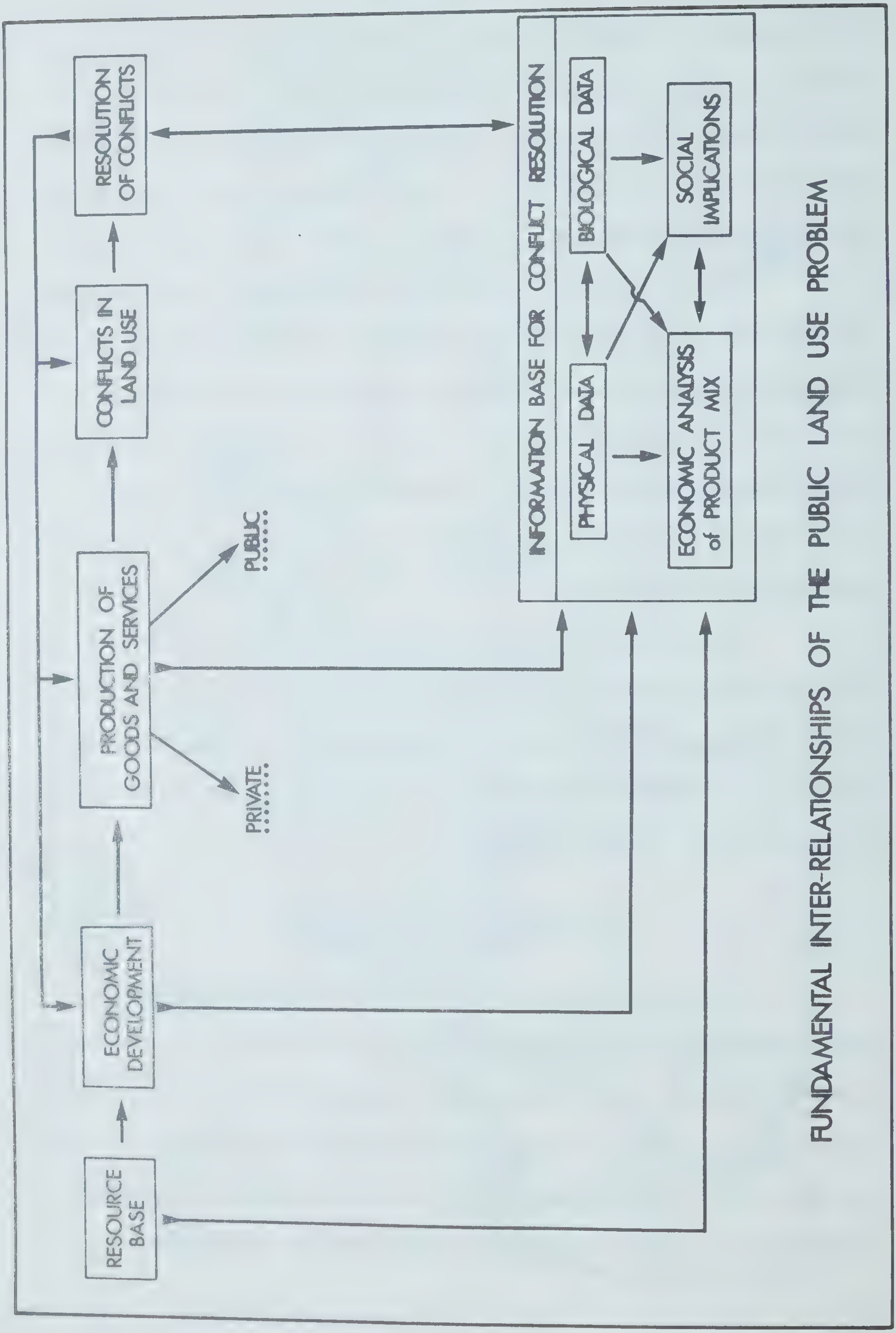
Figure B-1 depicts the role of planning in the resolution of land use conflicts. Land use conflicts can be viewed in the context of the resource base, its economic development and the resultant production of goods and services. Land use planning, which includes interpretation and integration of physical, biological, social and economic information, provides the decision-maker with a rational basis for land allocation.

Planning is a dynamic process. Conflict resolution in one area may have an impact on economic development in other areas which in turn may change the production of goods and services for a region and may even change the physical resource base. This in turn provides feedback to the planning process.

B2. ECONOMIC EVALUATION AND LAND USE PLANNING

Resource evaluation usually begins with information regarding physical and biological inputs and outputs. An inventory of natural resources, their locations, and alternative uses is required. Quantity and quality of non-renewable energy resources (coal, natural gas and oil) as well as mineral deposits will define the physical potential of mining and drilling operations in the region.

Figure B-1



FUNDAMENTAL INTER-RELATIONSHIPS OF THE PUBLIC LAND USE PROBLEM

Water resource development potential for hydro-electric power, irrigation, municipal and industrial uses, and water-based outdoor recreation is another major use category. Other renewable resource uses such as land for forestry, cattle ranching, outdoor recreation, and wildlife habitat form the third major use category. However these major use categories cannot be examined in isolation. Mining and drilling may have considerable impact on renewable resource use alternatives. This exemplifies the need for information regarding the interrelationships among the major use categories. Further, interrelationships within major use categories require examination, for example, hydro-electric development and sport fishing, and cattle ranching and wildlife management. Multiple land use evaluation should begin with use potentials and the physical and biological complementarity, substitutablity and competitiveness among these resource uses. Once this information is gathered it is then possible to develop physically and biologically feasible alternative resource use patterns. Only then can comprehensive socio-economic evaluation begin. Neither physical nor biological data are adequate in themselves for making decisions about resource allocation. Current planning systems commonly use subjective weighting scales to equate different units of productivity, ignoring pertinent economic trade-offs, and thereby risking inefficient resource allocation.

Economic evaluation can draw on a number of techniques such as activity analysis (e.g., linear programming and input-output analysis) and extra market value estimation techniques (e.g., willingness to pay and travel cost). However, an overall evaluation framework of benefit-cost analysis is desirable. The procedure may begin with measurement of social benefits and costs associated with existing resource uses in the East Slopes. Some resource uses, such as mining, forestry and agriculture have easily identified market values and lend themselves well to benefit-cost analysis. Others such as fish and wildlife, and outdoor recreation do not have easily identifiable market value and are more difficult to evaluate. Resource uses that defy measurement can be considered in terms of "safe minimum standards of conservation".[1]

There are external cost and benefits associated with resource use, such as soil, air and water pollution, and reduction

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[1]Multivalued decision problems are so common in economics that the objectives and criteria of conservation decisions are best formulated in a way that takes uncertainty explicitly into account. In certain instances the public policy objective must be reformulated, not in terms of maximizing a definite quantitative gain, but in terms of choosing policy alternatives whereby possible losses are minimized. This policy objective called safe minimum standard, is one of incurring costs in order to minimize the probability of high cost irreversible outcomes. See: S.V. Ciriacy-Wantrup, Resource Conservation: Economics and Policies. Division of Agriculture Sciences, University of California, Berkeley, 3rd ed., 1968, 395 pp.

in fish and wildlife habitat. External benefit may include improved access. These externalities, often ignored by private developers, should be taken into account in order to assess the value of resource use to society.

Evaluation of social benefits and costs, including externalities, will help to guide public policy for future development, tending to favor uses that offer the greatest social net benefits over time. However there are two related effects that must also be included in the evaluation. First, projected demand for the goods and services rendered by these priority uses may not increase sufficiently to permit development approximating physical and biological potentials. Second, social costs may increase at a rate higher than social benefits. So long as added social benefits exceed social costs, expanded resource use will be in the public interest. In some instances increased development can be of such magnitude as to affect the price of the goods or services it produces. This limits the usefulness of benefit-cost analysis unless such price changes are taken explicitly into account.

The external costs from resource development could render some development alternative uneconomic. For example, the irreversible loss of a substantial amount of wildlife is difficult to quantify. However, steps to insure against such loss (safe minimum standard) may call for certain restrictions on the development alternative. This method of dealing with high cost irreversibilities appears to have wide application in dealing with scenic values, wilderness values, fish and wildlife values and outdoor recreation values. The same development alternative may look even less attractive to society as a whole if alternative sites

outside the region offer similar prospects with far less external cost. For example, energy resource development sites outside of the East Slopes but within the province may be preferable to sites within the East Slopes in terms of external costs.

The discussion so far deals only with direct social benefits and costs; that is, those benefits and costs that arise directly from resource use. However, there exist indirect benefits and costs that have importance for measuring regional economic impact from resource development and management. Any development scheme will attract other activities such as retail services, banking, and other professional and trade services. Part of the income paid to project personnel is passed on to others not directly involved with the project and thereby generates secondary economic activity. Associated with this secondary activity are indirect benefits and costs and these can be measured with the aid of input-output analysis.[2]

When resource managers evaluate the performance or contribution of resource development they often consider a number of indirect, or secondary, benefits in their analysis which accrue from the entry of a resource user into a region. Principal among these benefits are employment, taxes, and growth and development resulting from the new

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[2] Input-output analysis allows measurement of the flow of goods and services within a region as well as in and out of the region. Thus, impact multipliers can be generated that indicate the indirect value to the region's economy of every dollar spent on the resource project.

investment.[3] The impact of these benefits varies according to whether they are considered from a regional, provincial, federal or international point of view.

The basic premise underlying classical economic theory is that resources are scarce and have alternative uses. Land, labor and capital in combination can be employed in a number of combinations and locations for a number of final outputs. These outputs will contribute to taxation, employment, and growth and development. To consider such benefits unique to a specific resource and resource user, when in fact they may be attributable to alternative resources and resource users, could result in an overstatement of benefits. If resources are scarce the benefits attributable to a specific industry or user group may actually constitute a transfer of benefits from one region to another. Therefore, caution must be exercised when secondary benefits are being considered. Depending on the level of analysis, and considering that these benefits may be attributable to all industry, secondary benefits may be "netted out".[4] Consider the feasibility of a pulpmill in the Whitecourt Forest or the Clearwater-

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[3] It is understood that employment is an important requirement for the function of our society. Taxation is a principal source of revenue for the operation of government. Growth and development is considered a desirable objective for national welfare and has an important impact on national income.

[4] The redistribution of economic activity (income redistribution) may be desirable from an equity point of view. Thus, while indirect benefits and costs should not be part of analyzing the resource allocation question, they are meaningful components of the incidence or income distribution question.

Rocky Forest. From the provincial point of view the appropriate measure of value can be estimated by the direct return; the impact of the secondary benefits will be the same. From the point of view of the Whitecourt region the secondary benefits, which would be foregone if a pulpmill is constructed in the Rocky Mountin House region, are important. The same reasoning applies as the analysis expands to a national point of view.

C. LAND AND SOIL OF THE EAST SLOPES REGION

C1. BACKGROUND INFORMATION

Figure C-1 shows the extent of soil surveys, land use studies, surficial geology, Eastern Rockies Forest Conservation Board guides, and Canada Land Inventory capability maps in southwestern Alberta. Of the 25 references listed for the above map only the Canada Land Inventory (C.L.I.) information provides continuous coverage of all of the land west of the fifth meridian, exclusive of the National Parks.

Soil and land surveys in the East Slopes area have been carried out over the past 30 years. Since concepts and methodologies change with time, some of the information needs updating. Differences of scale and objectives also influence the usefulness of the data.

The greatest deficiency in the soil and land information, especially for meso- and micro-scale[1] land use planning, is in the 40 per cent of the land between the Green Zone boundary and the National Parks for which there is virtually no soil survey information. However, 60 per cent of the East Slopes region has soil survey information. Figure C-1 also indicates that 18 per cent in the north part of the Green Zone is mapped at a very broad scale (Research Council of Alberta, Exploratory Soil Survey). Soil information was gathered throughout the entire East Slopes area during the course of the Canada Land Inventory

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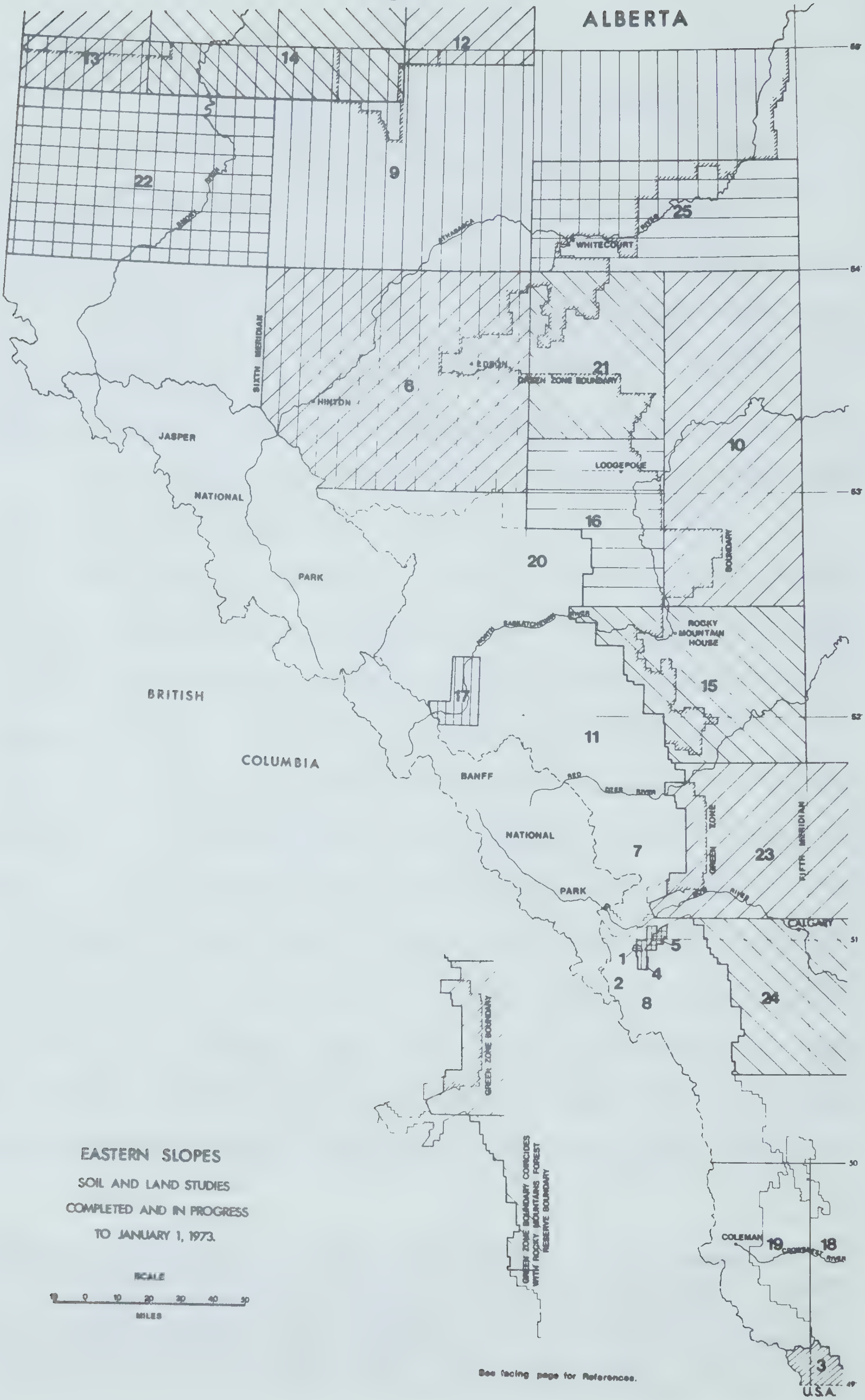
[1] In this presentation: "macro-scale" refers to the entire East Slopes region; "meso-scale" refers to an area that might concern a provincial planning commission such as the Oldman River Regional Planning Commission (Environment Conservation Authority, Information Bulletin No. 5); while "micro-scale" means land managed by an individual user that may contain very small parcels of land (10 to 1,000 acres).

Figure C-1


ALBERTA
BRITISH
COLUMBIA
JASPER
NATIONAL
PARK
BANFF
NATIONAL
PARK
SIXTH MERIDIAN
FIFTH MERIDIAN
WHITECOURT
EDSON
HINTON
LODGEPOLE
ROCKY MOUNTAIN HOUSE
CALGARY
COLEMAN
GREEN ZONE BOUNDARY
GREEN ZONE BOUNDARY COINCIDES WITH ROCKY MOUNTAINS FOREST RESERVE BOUNDARY
U.S.A.
EASTERN SLOPES
SOIL AND LAND STUDIES
COMPLETED AND IN PROGRESS
TO JANUARY 1, 1973.
SCALE
MILES
See facing page for References.

EAST SLOPES SOIL AND LAND STUDIES COMPLETED AND IN PROGRESS TO JANUARY 1, 1973

1. Beke, G.J. 1969. Soils of Three Experimental Watersheds in Alberta and Their Hydrologic Significance. University of Alberta, Dept. of Soil Science. PhD. thesis.

2. Boyacioglu, E. and N. Van Waas. 1972. Land Systems of the Kananaskis-Spray Drainage District. (The report was prepared for the Land Assignment Committee.)

3. Coen, G.M. and W.D. Holland - Land and Soil Resources and Interpretations for Waterton Lakes National Park. (In progress.)
   4"=1 mile 202 sq. m.

4. Crossley, D.I. 1951. The Soils on the Kananaskis Forest Experiment Station in the Sub-Alpine Forest Region in Alberta. Canada Dept. of Resources and Development. Silvicultural Research Note. No. 100.
   2"=1 mile 63 sq. m.

5. Duffy, P.J.B. and R.E.England. 1967. A Forest Land Classification for the Kananaskis Research Forest, Alberta. Dept. of Forestry and Rural Development, Forest Research Laboratory, Calgary. Internal Report A-9.
   4"=1 mile 24 sq. m.

6. Dumanski, J. and T.M.Macyk - Soil Survey of the Hinton-Edson area (83F). Alberta Soil Survey Report No. 32. (Soil maps published; soil report in press.)
   1"=2 miles 5,337 sq. m.

7. Eastern Rockies Forest Conservation Board. 1963-1972. 14 Conservation Unit Guides for Foothills Conservation Units. (East Slopes area, Green Zone only.)
   1"=3 miles

8. Karkanis, P.G. 1972. Soils of the Kananaskis Valley. University of Calgary, Dept. of Environment. PhD. thesis.

9. Lindsay, J.D., A.Wynnyk and W.Odynsky. 1963. Exploratory Soil Survey of Alberta Map Sheets 83L, 83K, 83F, and 83J. Research Council of Alberta, Preliminary Soil Survey Report 64-2.
   1"=12 miles 20,023 sq. m.

10. Lindsay, J.D., W.Odynsky, T.W. Peters and W.E. Bowser. 1968. Soil Survey of the Buck Lake (NE83B) and Wabamun Lake (E½83G) Areas. Alberta Soil Survey Report No. 24.
    1"=2 miles 4,222 sq. m.

11. Nowicki, J.J. 1971. Methodology of the Foothills Resource Allocation Study. Report No. 1. (Southern and Northern Foothills Regions, Athabasca excluded.)
    1972. Kananaskis-Spray Drainage District, Phase One. Preliminary Analysis.
    1"=1 mile

12. Odynsky, W., A.Wynnyk and J.D.Newton. 1952. Reconnaissance Soil Survey of the High Prairie and McLennan Sheets. Alberta Soil Survey Report No. 17.
    1"=3 miles

13. Odynsky, W., J.D.Lindsay, S.W.Reeder and W.Wynnyk. 1961. Reconnaissance Soil Survey of the Beaverlodge and Blueberry Mountain Sheets. Alberta Soil Survey Report No. 20.
    1"=3 miles

14. Odynsky, W., A.Wynnyk and J.D.Newton. 1956. Reconnaissance Soil Survey of the Grande Prairie and Sturgeon Lake Sheets. Alberta Soil Survey Report No. 18.
    1"=3 miles

15. Peters, T.W. and W.E. Bowser. 1960. Soil Survey of the Rocky Mountain House Sheet. University of Alberta Bulletin No. SS-1.
    1"=2 miles 2,500 sq. m.

16. Peters, T.W. - Soil Survey of the Brazeau Dam Area. (In progress.)

17. Pettapiece, W.W. 1971. Land Classification and Soils in the Rocky Mountains of Alberta along the North Saskatchewan River Valley. University of Alberta, Alberta Institute of Pedology #S-71-31.
    1"=0.8 miles 156 sq. m.

18. Stalker, A. 1958. Surficial Geology, Fort MacLeod Sheet. Geological Survey of Canada. Map 21-1958.
    1"=4 miles

19. Stalker, A. 1961. Surficial Geology, Fernie Sheet. Geological Survey of Canada. Map 31-1961.
    1"=4 miles

20. The Canada Land Inventory (A.R.D.A.). 1965. Objectives, Scope and Organization.
    Report No. 1. Dept. of Forestry Publication No. 1088.
    Report No. 2. 1965. Soil Capability Classification for Agriculture.
    Report No. 3. 1966. The Climates of Canada for Agriculture.
    Report No. 4. 1967. Land Capability Classification for Forestry.
    1970 - Second Edition.
    1972 - Reprinted.
    Report No. 5. 1968. The Economics of Plantation Forestry in Southern Ontario.
    Report No. 6. 1969.- Land Capability Classification for Outdoor Recreation.
    Report No. 7. 1970 - Land Capability Classification for Wildlife.
    (The C.L.I. land capability maps for agriculture, forestry, recreation, wildlife (ungulates and waterfowl) provide complete coverage except for the National Parks. There are 12 maps for each of the above sectors at the scale of 1"=4 miles, for a total of 60 maps west of the 5th meridian. There are 151 maps for each sector at the scale of 1"=1 mile, for a total of 755 maps west of the 5th meridian, available from the Technical Division, Alberta Dept. of Lands and Forests.)

21. Twardy, A.G. and J.D. Lindsay. 1971. Reconnaissance Soil Survey of the Chip Lake Area. Alberta Soil Survey Report S-71-28.
    1"=2 miles 2,132 sq. m.

22. Twardy, A.G. and T.M. Macyk - Soil Survey of the Wapiti Sheet (83-L). (In progress.)

23. Wyatt, F.A., J.D. Newton, W.E. Bowser and W. Odynsky. 1943. Soil Survey of Rosebud and Banff Sheets. University of Alberta, Bulletin No. 40.
    1"=3 miles

24. Wyatt, F.A., J.D. Newton, W.E. Bowser and W. Odynsky. 1960. Soil Survey of Blackfoot and Calgary Sheets. University of Alberta, Bulletin No. SS-2.
    1"=3 miles

25. Wynnyk, A., J.D.Lindsay and W.Odynsky. 1969. Soil Survey of the Whitecourt and Barrhead Area. Alberta Soil Survey Report No. 27.
    1"=2 miles 2,812 sq. m.

Areas NOT soil-surveyed within the Green Zone (exclusive of National Parks).
14,500 sq. m.

but not in sufficient detail or suitable format for interpretation for land uses such as townsite development, dam site development, and numerous recreational uses. For details on the use of soil surveys in land use planning see Bartelli et al (1966)[2].

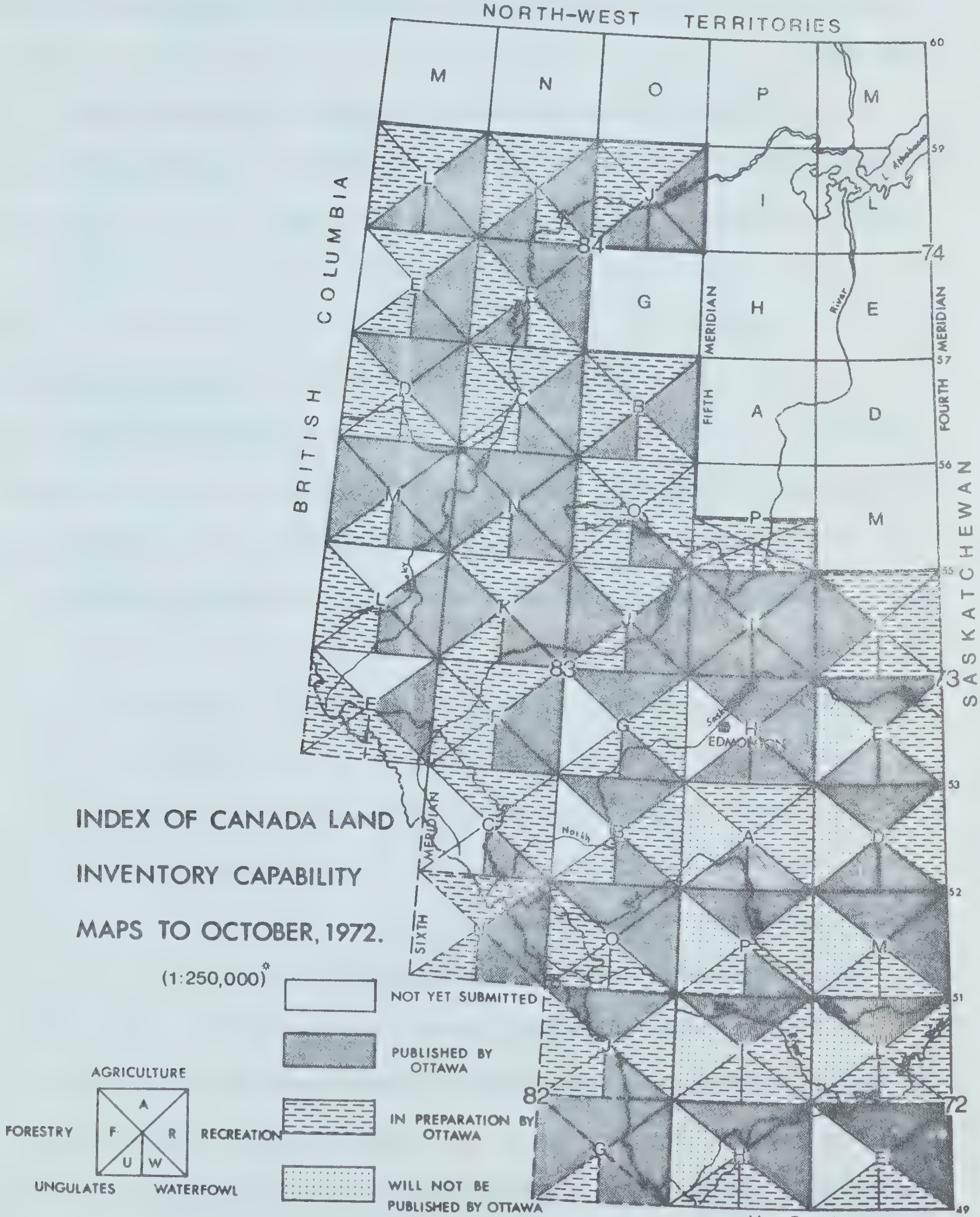
1a) THE CANADA LAND INVENTORY

The Canada Land Inventory is a national system for classifying land by inherent use capabilities for different purposes. It was established in 1965 with the objective of producing a series of interpretative maps using all existing knowledge of soil, climate, vegetation, or any factor other than economics. These maps indicate the degree of capability and limitation for certain uses. For the East Slopes region, west of the fifth meridian, there are a total of 60 sheets at a scale of 1:250,000 (1" = 4 miles) for the agriculture, forestry, ungulate, waterfowl, and recreation sectors (Figure C-2). There are 755 capability maps at a scale of 1:50,000 (1" = 1 mile). C.L.I. is the only inventory providing complete coverage of the East Slopes region and is an important source of data for the physical analyses of the area.

To be fully understood; C.L.I. references must be studies and underlying principles and assumptions appreciated. Some sectors, such as forestry, used quantitative parameters in classification, while others did not. The recreation sector employed attributes rather than quantifiable capabilities or limitations to recreational

[2] Bartelli, L.J. et al. 1966. Soil surveys and land use planning. Soil Sci. Soc. America and American Soc. of Agronomy.

Figure C-2



*IN ADDITION, THE C.L.I. MAP DEPOSITORY AT THE TECHNICAL DIVISION, DEPT. OF LANDS AND FORESTS IN EDMONTON HAVE ALL C.L.I. SECTOR MAPS AVAILABLE AT 1:50,000 SCALE.

use of land as the basis for classification. This poses problems in conventional land-use planning procedures employing quantitative criteria.

Although C.L.I. recreation ratings for the East Slopes are relatively low on the national scale (Table 1, Appendix II) they are relatively high in a provincial context.

C2. LAND USES

The C.L.I. capability distribution for agriculture, forestry, recreation, ungulates and waterfowl is summarized by Provincial Forest and physiographic province in Table 1, Appendix II. Comments here are limited to agriculture and some other uses not covered by C.L.I., as the remaining C.L.I. resources are dealt with elsewhere in the brief.

2a) AGRICULTURE

Agricultural uses include:

1. cereal crops such as wheat, oats, barley
2. pasture and hay crops
3. grazing of range cattle
4. irrigation reservoirs and canals

Topography, elevation, and climate are severe limitations to agricultural pursuits in the East Slopes region. Exceptions are few; for example, see the Canada Land Inventory Soil Capability for Agriculture (Fernie, 82G) which indicates an area of Class 2 land for agriculture near Lundbreck and Cowley. The general severity of the

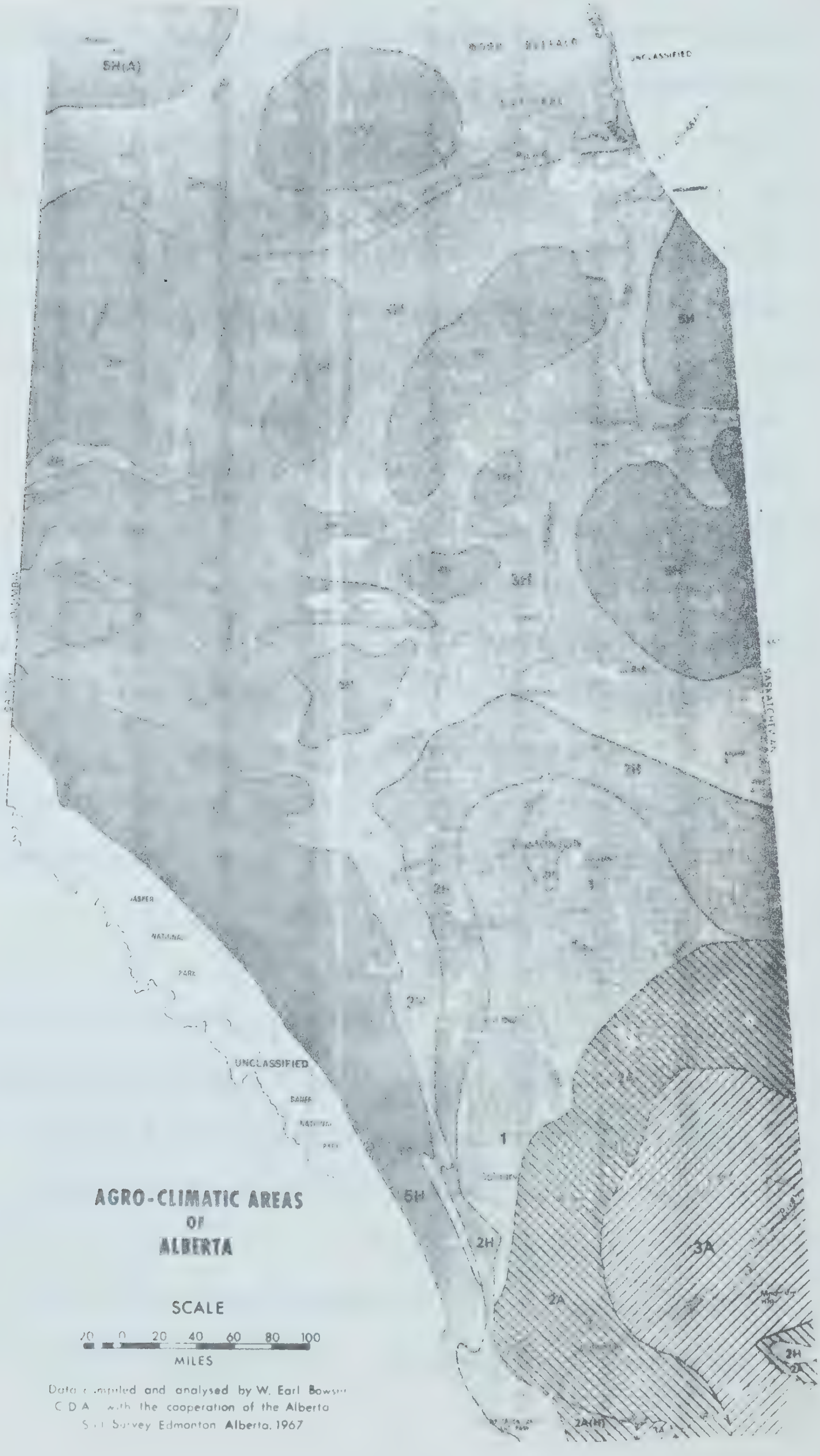
C.L.I. limitations for agriculture in the East Slopes area is further supported by Bowser's map (Figure C-3), an examination of which indicates that the East Slopes lie in a region designated by map unit 5H. This map unit consists of "areas where the amount of precipitation has usually been adequate but where the average frost-free period has been so short (generally less than 60 days) that it is not practical to grow cereal crops: that is, hay crops are all that are recommended." Further evidence of a short growing season is found in climatic data (Table 2, Appendix II).

2b) <u>OTHER LAND USES</u>

Many other land uses occur in the East Slopes, illustrated by the following examples:

1. Raw material source: - oil, gas, sulphur, coal, sand, gravel clay, peat, limestone.
2. Industrial sites: - pulpmills, oil and gas-processing plants, sulphur-extraction plants, cement plants, seismic lines, quarries, strip-mines, movies.
3. Institutional sites: -
    i. Research - Kananaskis Forest Experiment Station; Tri-Creek watershed project; Marmot, Deer Creek and Streeter Creek watershed basins; Hinton Forestry School; University environmental studies.
    ii. Youth camps.
    iii. Provincial - Nordegg jail.
4. Watershed management: - (other than research)

Figure C-3


5H(A)
UNCLASSIFIED
JASPER
NATIONAL
PARK
UNCLASSIFIED
BANFF
NATIONAL
PARK
5H
1
2H
2A
3A
2A(H)
2H
AGRO-CLIMATIC AREAS
OF
ALBERTA
SCALE
20 0 20 40 60 80 100
MILES
Data compiled and analysed by W. Earl Bowser
C.D.A. with the cooperation of the Alberta
Soil Survey Edmonton Alberta, 1967

LEGEND

This map delineates areas that have, on the long-term average, similar climatic characteristics for cropping purposes. It is an attempt to provide a general guide in determining the range of crops that, as a result of a combination of climatic factors, can be satisfactorily grown in each area. It must be emphasized that climate is only one of the physical factors that influence the range of crops grown; there are others, particularly soil type and topographic features.

THE LINES DIVIDING THE AREAS ARE USUALLY BROAD TRANSITION BELTS; RARELY IS THERE A SHARP CHANGE IN CLIMATE FROM ONE AREA TO ANOTHER.

The area boundaries are delineated by broken lines to indicate that they are subject to change when additional data becomes available. Local topographical features and proximity to lakes and muskegs can cause local conditions: cold "frost pockets"; exceptionally good air drainage with longer than normal frost-free periods; warm belts; areas with heavy dew formation; and areas with more or less precipitation than the average for the larger area. These conditions may differ significantly from the average for the area but cannot be shown on a map of this scale. The frost-free data quoted in the area descriptions are long-term averages. It is recognized that throughout most of Alberta the average frost-free period since about 1950 has been significantly longer than for the period of record before that date. For the purpose of this map, however, the 1950-1965 period has been considered as an anomaly and not as a trend.

The map was compiled in collaboration with members of the Alberta Soil Survey using information taken from: (1) publications of the Meteorological Service of Canada, (2) *Climates of Canada for agriculture*, CLI Report No. 3 by Chapman and Brown of the Ontario Research Foundation, (3) *The frost-free period in Alberta* by R. W. Longley of the University of Alberta, (4) data and observations gathered by members of the Alberta Soil Survey, and (5) observations by grain elevator agents and federal and provincial field personnel. Recognition is also given for suggestions and data provided by Dr. A. Leahey, G. W. Robertson, and J. Day, of the Canada Department of Agriculture, Ottawa. The map was initially compiled to assist the Soil Survey to determine the capability of Alberta soils for agricultural use. The Arabic number designation of the areas indicates relative capability: 1 being top, or best. The subscript A (aridity) indicates that moisture is the limiting factor. The subscript H (heat) indicates that such factors as summer heat units, frost-free periods, and days between peak summer rainfall and first fall frost, are limiting factors.

1 Areas where the amount of precipitation has usually been adequate and the frost-free period long enough to permit the growing of all the dryland crops that are typical to the Prairie Region of Western Canada. The frost-free period in these areas has averaged over 90 days and the annual precipitation has averaged 16 to 18 inches.

2A Areas where the amount of precipitation, in approximately 50 percent of the years, has been a limiting factor to crop growth. The frost-free period has usually been long enough for wheat to mature without frost damage. In the 2A(H) area south of Lethbridge there is some frost hazard

3A Areas where the amount of rain has usually been a severe limiting factor to crop growth; a wheat-fallow rotation is practiced to the virtual exclusion of all other rotations. The annual precipitation has averaged 12 inches. The frost-free period has averaged slightly over 100 days in the northern portion of the area and over 115 days in the south central portion. Wheat is rarely damaged by frost and sweet corn can be grown, under irrigation, in the southern portion.

2H Areas where the amount of precipitation has usually been adequate but where wheat has suffered some frost damage in approximately 30 percent of the years. The frost-free period has averaged between 75 and 90 days

3H Areas where the amount of precipitation has usually been adequate but where it is not considered practical to grow wheat because of the frequency of damaging frosts. In the areas south of Latitude 55° N the average annual precipitation has averaged 17 to 19 inches. Going north from Latitude 55° N there is a gradual drop in precipitation and at Fort Vermilion the annual average is between 12 and 13 inches.*

5H Areas where the amount of precipitation has usually been adequate but where the average frost-free period has been so short (generally less than 60 days) that it is not practical to grow cereal crops; that is, hay crops are all that are recommended.*

UNC Mountain complex and Precambrian Shield. There is little to no agricultural potential in these areas.

*The portion of the province north of Latitude 58° N has an average annual precipitation of less than 14 inches. In most of this area rainfall, or lack of rainfall, may be an additional limiting factor to crop growth in a significant number of years. Therefore the 3 and 5 areas that, in general, lie north of Latitude 58° N are given the limiting subscript A in addition to H; i.e., 3H(A) and 5H(A).

5. Conservation: -

    i. Ecological reserves (e.g. Simonette basin)

    ii. Protection forest - generally over 6,500 feet elevation and zoned[3] as non-commercial because of its value for erosion control and water yield.

6. Transportation: - Considerable amounts of land are required for highways and railways, particularly through the mountain passes where the valleys are narrow and suitable land is limited in extent. Other transportation uses, such as secondary roads, airports, pipelines, power lines, and irrigation canals also use land, but their location is not confined to the main transportation corridors as they are distributed throughout much of the East Slopes region.

7. Hydro-electric: -

    i. Reservoirs

    ii. Dams and associated borrow pits.

8. Indian reserves: - At least 5 in the East Slopes region.

9. Townsites: - 5 townsites and 57 villages and hamlets are presently situated within the Green Zone. Another 8 townsites are on the fringe of the Green Zone boundary.

10. Airports: - The use to which East Slopes land will ultimately be committed depends on many factors, some of which are discussed in the following section.

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[3]Zonation of "protection forest" is defined by the Alberta Department of Lands and Forests.

C3. SOME FACTORS AFFECTING LAND USE

3a) LOCATION

East Slopes land is adjacent to the population centres of Lethbridge, Calgary, Red Deer, Edmonton, and Grande Prairie. The land receives additional use pressure as a result of its location on the main corridor routes to British Columbia. The East Slopes region has an excellent location continentally. It is possible to travel by air from a population centre such as Los Angeles California and be in the East Slopes region in less than a day.

The three main corridors through the mountain passes, and the connection to the National Parks via the Upper Saskatchewan River valley have relatively good standards of transportation facilities with respect to highways, railways, and airports. The distribution of facilities is dictated by the physiography of the region.

Secondary roads, including the Forestry Trunk Road and oil and gas and pulp company roads provide access to most of the remaining area. The distribution of secondary roads is deficient in some areas, particularly south and west of Calgary where private property blocks access in some crown land in the Forest Reserve.

Future access development should be a prominent aspect of land use policy in the East Slopes.

3b) PHYSICAL FACTORS

The East Slopes region may be divided into 5 physiographic provinces as defined in Table C-1. Their distribution and location are shown in Figure C-4.

Numerous physical factors affect the kind and degree of land use that occurs in the East Slopes. For example because of differences in climate and topography forestry practices can be more intensive in the Low Foothills than in the Mountain province, and land management in general may be more difficult and hence more costly in the High Foothills than on the Plains. Productivity is not the same in all provinces, nor is the land capability the same (Table 1, Appendix II).

Depending on kind of use, intensity of use, and levels of land management, physical factors have varying effects on land use. Steep topography may preclude logging activities but may be excellent for mountain climbing. The quality of soil available also affects land use. A certain kind of land may have a porous gravelly soil that is level and dry for camping, but its permeability may pose a pollution hazard to downstream users because effluents readily pass through the soil.

In general, land varies in its capability to withstand human activity and intensity of use should be matched to capabilities of the soil and land to withstand it. Forest vegetation, which occupies a large proportion of East Slopes land, is affected by a

TABLE C-1. PHYSIOGRAPHIC P

(within Green Zone

Physiographic Provinces	Area (Sq. M.)	Elevation Range (in feet)	Topography Range	Slope Range and Mean Slope in %	Slope Length
1. Mountain	4,799	6,000 +	Rugged; steep slopes, deep valleys	30 - 100 50	Long, 1 mile
2. High Foothills	4,445	5,000 - 6,000	High rounded hills; steep eroded escarpments on west side - long slopes on east side - deep valleys	20 - 70 30	Mod-Long, 1 Mile - >1 Mile
3. Low Foothills	6,450	4,000 - 5,000	Low, rounded, broad, rolling hills; incised valleys	10 - 30 15	Short, 100 yrds.
4. Alberta Plains	16,721	<4,000	Undulating to gently rolling; contains glacial spillways and incised river channels.	0 - 15 8	Short, 100 yrds
5. Valleys:			Broad U shaped valleys with small hills, small till plains, broad terraces	0 - 30 15	Mod-short 1 Mile - 100 yrds.
a. Athabasca	236	<4,000			
b. North Sask.	222	<5,000			
c. Bow	100	<5,000			
d. Crowsnest	51	<5,000			
	609				
Total:	33,024 square miles				

OVINCES ON THE ALBERTA EAST SLOPES REGION
to 55°N except 83J)

Geology	Surficial Materials	Soils	Climate	Forest Characteristics
Mesozoic shales, sandstones, conglomerates, limestones, dolomites, strongly folded, faulted parallel mountain ranges	35% Rock outcrop residual at high elevation. 30% Cordilleran glacial drift. 30% Colluvium on steep mountain sides. 5% Alluvium along streams in valley bottoms	Numerous mountain peaks and rock outcrop. Mostly coarse textured very stony Gray Wooded; Podozolic soils at higher elevation. Brunisols and Regosolsin on steep mountain sides. Mostly well drained Chernozemic soils in grassy areas in Southern region.	Cool, subhumid to humid; with many local variations due to mountainous terrain. Lower temperatures and higher precipitation than in physiographic units lying at lower elevations.	Interspersed within the bedrock are sheltered places with pockets of deeper soil. Tree species are alpine fir, limber and whitebark pine, Engelmann spruce
Uplifted Mesozoic shales and sandstones with some local Cambrian limestones	60% Cordilleran glacial drift. 20% Colluvium, 10% Alluvium, 10% Residual and Rock	Mostly coarse textured, well drained, Gray Wooded and Bisequa Gray Wooded.	Cool, subhumid. Greatly influenced by the Chinook winds. Short growing season.	Mainly coniferous forest. Characteristic species are Engelmann spruce, Engelmann-white spruce hybrids, alpine fir, lodgepole pine.
Uplifted and folded Mesozoic and late Palaeozoic sediments are overlain by glacial deposits.	60% Cordilleran glacial till. 20% Lacustrine, 10% Alluvial, 10% Organic	Mostly medium textured, well drained Gray Wooded soils.	Moderately warm summers, cold winters. 60% of the precipitation falls during growing season.	Mostly coniferous forest. Major species are white spruce, lodgepole pine with black spruce north of Red Deer River
Continental glaciation covered the Mesozoic sedimentary rocks with a drift of variable composition.	45% Continental till 35% Lacustrine 5% Alluvial 15% Organic	Mostly fine to very fine clay loams to clays, well drained, Gray Wooded to poorly drained Organic soils.	Continental, warm summers and cold winters.	Coniferous and deciduous forest. Tree species are lodgepole pine, white spruce, aspen, balsam poplar, balsam fir and black spruce.
The underlying rocks are altered or contorted Palaeozoic and Mesozoic sediments.	30% Cordilleran till 40% Glacio-fluvial 30% Alluvial	Mostly coarse textured outwash soils, strongly calcareous, very droughty, much variation by individual valley.	Dry, windy gaps. Chinooks more frequent.	Bow, Crowsnest and North Saskatchewan dominantly grass with open aspen clumps. Athabasca Valley has minor amount of grass, mostly aspen at lower elevation, lodgepole pine at higher sites.

Figure C-4


SIXTH MERIDIAN
FIFTH MERIDIAN
ALBERTA
BRITISH
COLUMBIA
EDSON
HINTON
JASPER
NATIONAL
PARK
BANFF
NATIONAL
PARK
ROCKY MOUNTAIN HOUSE
CALGARY
WATERTON NATIONAL PARK
U.S.A.
EASTERN SLOPES
PHYSIOGRAPHIC PROVINCES
1. MOUNTAINS
2. HIGH FOOTHILLS
3. LOW FOOTHILLS
4. ALBERTA PLAINS
5. VALLEYS
SCALE
MILES

combination of physical and human factors and is discussed in detail in a number of texts.[4,5,6] The effect of physical factors on land use must not be ignored if good land management policy is to be achieved.

3c) HUMAN FACTORS: (POLICY AND THE APPLICATION OF KNOWLEDGE)

Knowledge of soil and land can be used to improve land use policy and to make decisions pertaining to land management. Much information already exists (Figure C-1) and decision-makers (public or otherwise) should be aware of the information available. The public should also be aware that government agencies are currently applying the knowledge on hand in resource allocation studies.[7,8] The continuation of such studies is necessary to assist in the development of land use policy.

The East Slopes region is in a unique geographic situation, lying between areas of land for which policy is established.

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[4] Daubenmire, Rexford F. 1959. Plants and environment; a textbook of plant autoecology, 2nd ed. John Wiley, New York.

[5] Odum, Eugene P. 1963. Ecology. Holt, Rinehart and Winston, New York.

[6] Braun-Blanquet, J. 1932. Plant sociology: the study of plant communities. Translated, revised and edited by George D. Fuller and Henry S. Conrad.

[7] Nowicki, et al. 1972. Foothills resource allocation study. Kananaskis - Spray Drainage District, Phase I. Preliminary analysis. Multiple use Planning Section, Forest Land Use Branch, Department of Lands and Forests, Edmonton.

[8] The Research Planning Section, Provincial Planning Branch, Department of Municipal Affairs, is currently preparing a study on the Hinton-Yellowhead area.

Provincial policy on the agricultural lands adjoining to the east will influence policy for East Slopes land. Similarly, National Parks land to the immediate west is under the influence of another policy and a very different kind of land use. Assume for a moment that the East Slopes land should become highly industrialized[9]. The resulting shortage of suitable alternative sites for many recreational uses illustrates the importance of public policy in future land use and development of the area.

C4. INTERPRETATION OF PRESENT KNOWLEDGE

4a) SOIL

A gap exists in the knowledge of soils of the East Slopes, but sufficient knowledge is available for initial planning purposes.

The total quantity of soil available is synonymous with the gross land area except in the Mountain physiographic province where much of the land surface is exposed bedrock. At a macro-scale all soil Orders are present in the East Slopes with the possible exception of the Solonetzic Order, according to the System of Soil Classification for Canada. Most of the soils are probably in the Gray Wooded, or Luvisolic soil Order. Well developed Podzolic soils

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[9] Land very similar to that of the East Slopes region of Alberta has been committed to industrialization in the State of Colorado (largely as a result of the aero-space program). An examination of the impact of this policy may be of assistance to the development of policy for Alberta.

occur in some of the higher elevations and in moister physiographic provinces. Most of the poorly drained and highly organic (peaty) soils occur in the northern and eastern portions of the region. Black soils (Chernozemic) occur in the souther parts - Bow Valley and south into Waterton Park. The Gray Wooded and Podzolic soils indicate environmental conditions generally favorable to forestry pursuits. Poorly drained and peaty soils are indicative of areas of water reserves. Black soild (Chernozemic) are usually in drier locations and support a more grassy type of vegetation. Hence, a broad zonation of land is available.

These soils have a wide range of characteristics[10] that affect soil quality[11]. Differences in soil quality increase in magnitude of importance in progression from macro- to micro-scales of consideration for both planning and management. At the micro-scale level public agencies and private individuals managing specific parcels of land must know the characteristics and qualities of the soils that they are managing. For example, roads or trails should be

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[10] Soil characteristics refer to physical and chemical features such as particle size distribution, soil structure, stoniness, amount of lime, acidity, amount of organic matter, etc.

[11] Soil qualities refer to the inferred soil properties resulting from various combinations of physical and chemical characteristics and are designated by such terms as erodability, productivity, permeability, fertility, etc.

located and designed to avoid erosion. Soil characteristics affect sewage lagoon installations, flood risks, and building stability.

The assessment of soil qualities for recreation depends very much on the kind of recreation and the intensity of the activity. For example, some intensively used campsites or tenting sites under present forms of management may accommodate more people per acre than some high-rise developments in downtown Edmonton or Calgary. That is not to say that that such forms of management are good or bad. There are certain advantages if a policy of concentrated land use, or zoning, is followed. Concentrated use reduces the cost of fire protection and garbage collection, but greater effort must be extended in the selection of sites that have a high capability for vegetation stability as well as having soils that resist the human impact of wear and tear and possess high qualities for effluent absorption without undue pollution hazard. Also, sites put to an intensive use for campsites may have a shorter life span than those not so heavily used, leading to increased capital expenditure for developing new sites, as well as a more frequent occurrence of reclamation costs on the old, worn out, or abandoned campsites. A policy of land use dispersal would necessitate increased costs for roads, as well as fire protection and maintenance as noted above, but the benefits to the user, and his willingness to pay, may be increased.

All soils are fragile to some extent for recreation, or any other land use, if they are improperly managed. To the extent of

present knowledge, the soils of the East Slopes are suitable for many forms of recreational use. Climate and slow rates of vegetation growth, especially at the higher elevations, probably have as much influence on recreational use as soils.

With application of soil knowledge and good soil management recreational uses in the East Slopes can be maintained and even increased in the future.

4b) RESOURCE ALLOCATION STUDIES

Resource allocation studies for the East Slopes have been carried out, or are in progress, the best known ones being the work of the Forest Land Use Branch, Department of Lands and Forests (The Foothills Resource Allocation study) and the Provincial Planning Branch of the Department of Municipal Affairs. Such studies, are to be encouraged and applauded for the knowledge being acquired and for the development and/or application of analytical procedures, especially for translating the findings of the Canada Land Inventory into a form useful for planners.

Both systems use C.L.I. information as a data base for renewable resource capabilities. The Foothills Study added other information pertaining to the capability of land for non-renewable resources such as oil, gas and coal. Both use a "weighting" of various capabilities to develop preferred use maps. The two systems used are similar in concept, but differ in detail. These studies have been too slow to meet the urgent needs of the land

user planners and managers, and much of the information would be easier to read and interpret if it were presented in color map form rather than computer print-out. Also, there would appear to be an advantage in concentrating the work being done by various agencies into one overall agency. At least the analyses would be uniform over an entire region such as the East Slopes instead of having two major inputs using slightly different methodologies.

C5. FUTURE PLANNING AND DEVELOPMENT

In the future, as policy makers, planners and resource managers progress toward a more detailed consideration of land use and development in the East Slopes, soil and land information and its interpretation in terms of suitabilities and limitations for specific uses will become increasingly more important.

D. THE CLIMATE OF THE EAST SLOPES

D1. METEOROLOGICAL STATIONS

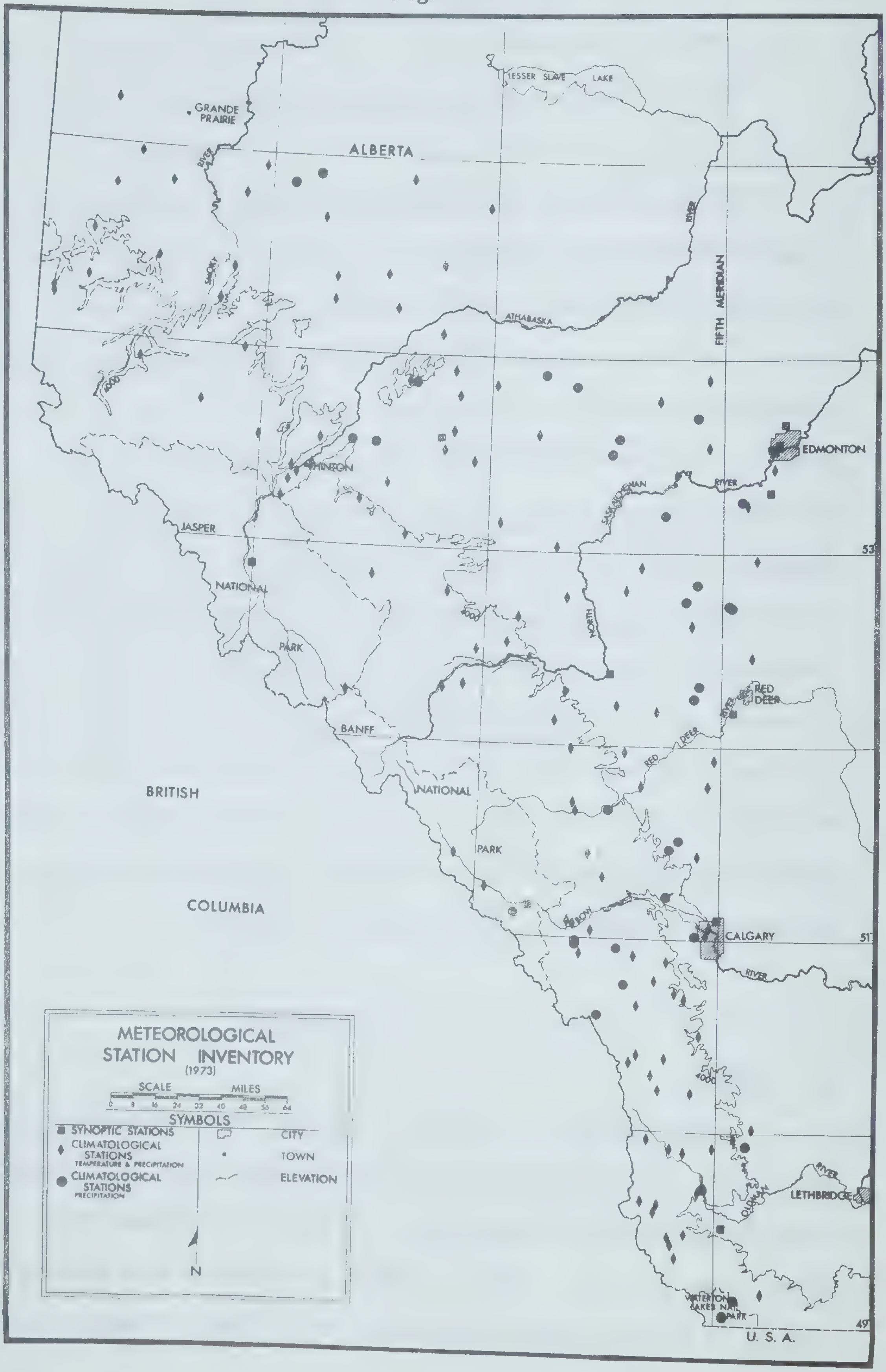
Meteorological data aquisition programs utilizing a synoptic network (first order stations) and supplementary networks (climatological stations) are conducted by the Atmospheric Environment Service, D.O.E. Most of the climatological stations that measure temperature and precipitation in the East Slopes are operated by the Alberta Forest Service. The Federal D.O.E. processes and archives these data and prepares regional climatological reports and data summaries. Station locations depicted in Figure D-1 include 10 synoptic stations, 114 climatological and forestry stations that measure temperature and precipitation plus 34 precipitation storage gauge locations. It should be noted that the network density is low in the central and northern forests of the region and the majority of Alberta forestry stations are not operational in the winter. There is a definite need for more climatological stations with a continuous observational program for use in land use planning and water management programs.

D2. CLIMATOLOGICAL SUMMARY

2a) GENERAL

In general, the climate of the East Slopes can be characterized as complex, varying altitudinally, latitudinally, and with aspect. The scarcity of permanent observation stations (only one year-round station above 5,000 feet a.s.l. prior to 1961) and the fact that existing stations tend to be either in valley bottoms or on hilltops, makes it impossible

Figure D-1


METEOROLOGICAL
STATION INVENTORY
(1973)
SCALE MILES
0 8 16 24 32 40 48 56 64
SYMBOLS
SYNOPTIC STATIONS
CLIMATOLOGICAL STATIONS TEMPERATURE & PRECIPITATION
CLIMATOLOGICAL STATIONS PRECIPITATION
CITY
TOWN
ELEVATION
N
ALBERTA
BRITISH
COLUMBIA
GRANDE PRAIRIE
LESSER SLAVE LAKE
ATHABASKA
FIFTH MERIDIAN
RIVER
SMOKY
EDMONTON
SASKATCHEWAN
RIVER
HINTON
JASPER
NATIONAL
PARK
NORTH
RED DEER
RED
DEER
RIVER
BANFF
NATIONAL
PARK
CALGARY
RIVER
LETHBRIDGE
WATERTON LAKES NAT. PARK
U. S. A.
4000

at present to map isolines of temperature or precipitation on a large scale or "true" map (scale greater than 1:1,000,000) with any degree of confidence. In short, climatic data presently available are useful for a broad description of the climate but insufficient for land use planning programs such as site location. This is a problem common to all mountainous areas. The natural variability of climatic elements and complexity of meteorological phenomena is so great in mountainous terrain that the "true" climate can not be defined by standard national climatological networks. Height-dependency curves of various elements and other devices are useful in detailed modelling of climate but a "blind" use of such techniques can give misleading results. Although present data networks and meteorological information are only suited for a general description of the climate more precise information could be produced using present data and meteorological expertise.

Table D-1 shows climatological data for selected stations. Figures D-2 and D-3 are maps of mean daily temperature for July and January[1].

Mean temperatures in July over the East Slopes area range from the low sixties in the Pincher Creek district to 55°F in the central and northern forests. Mean Maximum temperatures are 70 to 75°F and mean Minimum temperatures are near 45°F. These summer temperatures are lower than on the prairies due mainly to the higher elevation and also due to more cloud and rain that occurs over the East Slopes in summer.

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[1] Longley, R.W. 1972. The climate of the prairie provinces. Climatological Studies No. 13. Environment Canada, Atmos. Envir. Serv. 79 pp.

TABLE D-1 CLIMATOLOGICAL DATA FOR SELECTED STATIONS IN THE PRAIRIE PROVINCES

Station	Elevation (feet)	Temperature - Degrees Fahrenheit											Mean Dates of Frost		Effective Growing Season Average Dates (1)		Annual Growing Degree-day Normals (2)	Precipitation (inches)	
		Mean Annual	Mean Daily Maximum				Mean Daily Minimum				Extreme Low	Extreme High	Last in Spring	First in Fall	Beginning	Ending		Mean Annual Total	Mean Annual Snowfall
			Jan	Apr	Jul	Oct	Jan	Apr	Jul	Oct									
Calgary	3540	38.4	24.3	49.4	78.4	53.2	4.0	27.3	49.2	30.3	-49	97	May 27	Sept 11	-	-	2365	17.44	58.5
Edmonton	2219	36.9	15.2	50.0	74.4	51.6	-2.0	28.9	51.7	30.7	-57	99	May 18	Sept 19	Apr 26	Oct 7	2596	18.64	53.8
Fort McMurray	1213	31.0	3.8	47.8	75.5	47.2	-16.4	21.7	47.7	26.2	-59	96	June 19	Aug 19	May 1	Sept 29	2154	16.85	50.0
Fort Vermilion	915	29.1	0.0	44.8	74.7	43.9	-18.9	21.4	48.6	24.5	-78	103	June 6	Aug 22	Apr 27	Sept 29	2320	13.92	50.9
Grande Prairie	2190	34.5	12.1	47.0	71.8	48.3	- 5.9	27.0	48.8	27.9	-62	94	May 21	Sept 7	May 1	Oct 5	2205	17.27	65.5
Lethbridge	3018	41.8	27.3	53.4	79.9	56.8	7.2	30.1	52.0	33.8	-45	104	May 22	Sept 17	Apr 27	Oct 12	3057	17.23	65.7
Medicine Hat	2365	41.5	22.4	55.0	83.1	57.7	1.8	31.4	55.1	33.2	-51	108	May 14	Sept 20	Apr 21	Oct 19	3365	14.29	48.7
Red Deer	2820	36.8	17.8	49.6	74.3	53.2	- 2.2	28.0	50.1	28.4	-59	99	May 31	Sept 8	Apr 25	Oct 10	2158	21.44	49.2
Banff	4583	36.0	21.7	47.7	72.5	49.3	3.5	25.2	43.5	29.3	-60	94	June 17	Aug 21	May 5	Sept 30	1812	18.48	79.3
Edson	3033	35.3	18.7	50.2	73.0	51.2	- 1.9	24.1	44.4	25.5	-55	100	June 19	Aug 22	-	-	-	20.85	58.7
Jasper	3480	37.3	21.0	50.2	73.6	51.2	3.0	26.4	45.2	30.2	-52	98	June 10	Aug 27	May 1	Oct 5	1975	15.98	49.2
Rocky Mtn.House	3330	37.1	19.6	49.0	72.2	52.6	1.4	27.2	48.4	29.4	-44	91	June 9	Aug 22	-	-	2097	21.20	66.9
Wagner	1915	34.0	11.7	46.0	70.8	48.0	- 5.5	25.0	50.2	29.5	-51	92	June 4	Sept 8	May 1	Sept 28	1997	16.57	54.4
Whitecourt	2430	34.2	14.8	49.2	72.9	50.0	- 4.8	24.6	46.5	26.0	-58	93	June 10	Sept 4	-	-	1910	20.31	60.3

(1) Boughner, C.C., 1964: The Distribution of Growing Degree Days in Canada. Canadian Meteorological Memoirs 17. Meteorological Branch - DOT (now Atmospheric Environment Service, Downsview, Ont.)

(2) Aston, D., 1969: Growing Degree-Day Normals Above 42°F - Based on the Period 1953-1967. CDS #3-69. Meteorological Branch - DOT (now Atmospheric Environment Service, Downsview, Ont.)

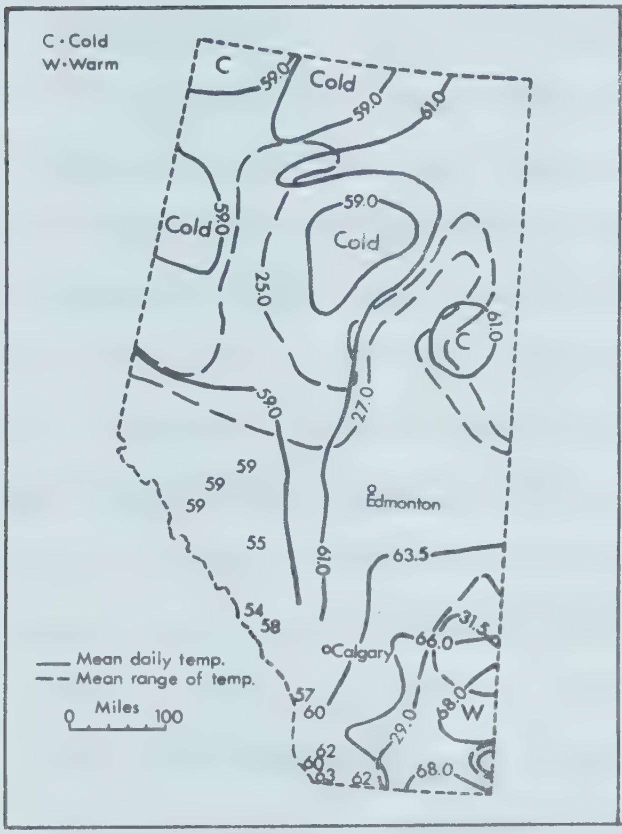

Figure D2. Mean daily temperature and mean range of temperature for July (°F).

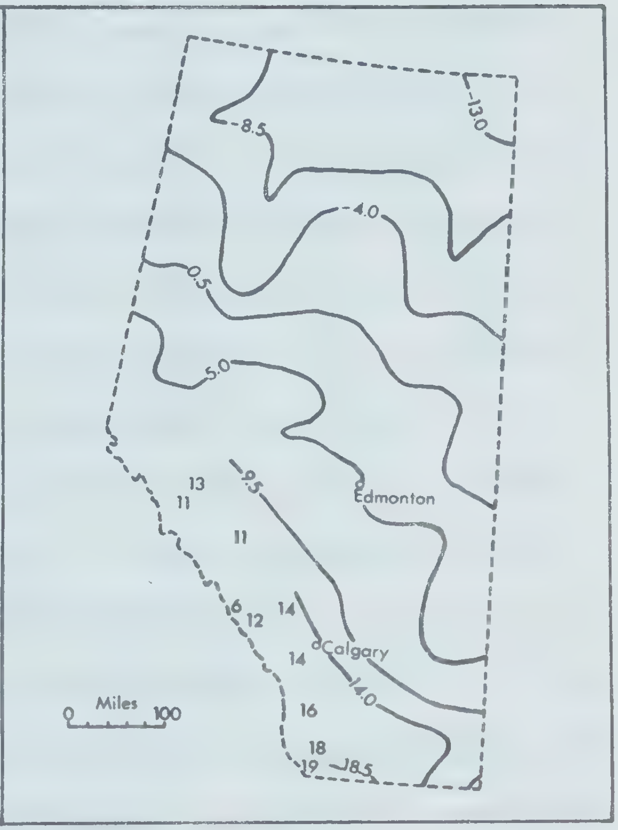

Figure D3. Mean daily temperatures for January (°F).

(after Longley, 1972)

In winter, the mean daily temperatures for January range from 19°F at Carway near the Montana border to 5 to 15°F in the central and northern forests. These mean winter temperatures are about 15°F warmer than central Saskatchewan. There are several reasons for the milder winters, namely the higher elevation, Chinooks, and the proximity to milder air over British Columbia. Mild spells in winter usually start first and last longer over the East Slopes area as the mild air enters Alberta from B.C. Sometimes pockets of cold air are trapped in mountain valleys and the mild air aloft resurfaces farther east, especially in southern Alberta.

Terrain is so important to the local climate that it is impossible to give details for each individual mountain and valley. The results of research studies of the Marmot Creek Basin confirm that there are significant variations in the local climate of the East Slopes region.

Weather recording instruments have been set up at different elevations and with different exposures on the slopes and valleys of the Marmot Creek Basin. Precipitation, radiation, temperature and wind measurements are being taken and studies are being carried out on snow-melt, runoff, stream flow, erosion, and the effects of cutting forests. A few of the results are given in Table D-2 to illustrate the variations in climate in one basin in the East Slopes area.

TABLE D-2. 1965 Data for Marmot Creek Basin[1]

OBSERVING POINT	Con 1S[2]	Con 4V	Twin 8S	Twin 3S	Cabin 3N
Elevation (Feet above M.S.L.)	5300	5600	6100	7200	7300
July Mean Maximum Temperature	70.6	68.7	66.6	69.8	59.4
July Mean Minimum Temperature	45.7	41.5	45.0	49.7	41.7
August Mean Maximum Temperature	68.7	66.7	66.7	68.5	55.6
August Mean Minimum Temperature	46.2	42.6	48.6	54.4	40.0
September Mean Minimum Temperature	29.0	26.7	33.9	35.6	21.2
Total July Precipitation (inches)	2.18	2.54	2.61	2.94	2.49
Total August Precipitation (inches)	4.39	4.81	4.65	4.44	4.18

MEAN WIND VALUES FOR DECEMBER

Con 4V - 5600 Feet M.S.L.	Northwest	4.9 Miles per hour
Upper - 8000 Feet M.S.L.	West	13.5 Miles per hour

NOTE: - Temperatures are in degrees Fahrenheit

- S - South-facing location
- N - North-facing location
- V - Valley location

[1] Storr, D. A.E.S. Research hydrometeorologist, Calgary. Personal Comm.

[2] Designations for station in different sub-basins within the Marmot Creek Basin.

Comparing the temperatures in Table D-2 at Cabin 3 with the weather station at Twin 3 illustrates the rule that north-facing locations are normally colder than south-facing locations. The usual rule that temperatures in summer are colder at higher elevations is shown by most of the stations in the table but Twin 3 is a notable exception with its high values in 1965. It should be pointed out that several years of data are required before definite climatological conclusions can be drawn from such statistics. However, proper use of short data records or detailed surveys in land use planning can minimize inclement local weather effects.

Anyone planning on developing a recreational area, ski resort, or townsite would be well advised to undertake a detailed study of the weather conditions in the area before proceeding. For example, the mean wind values for December 1965 at a valley station (5,600 feet) in Marmot Basin was northwest at 4.9 miles per hour while at 8,000 feet the mean wind was west at 13.5 miles per hour. Also temperature and precipitation patterns, length of growing season, in fact the local (meso- or micro-scale) climate, varies considerably with elevation. The cause of the variations is not due, however, only to differences in elevation. Thus planners should consult a specialist in this scale of meteorology. Central Services Directorate of the Atmopsheric Environment Service provides consultation and advice regarding such matters.

2b) CHINOOK WINDS

Chinooks are warm dry winds which are a special climatic phenomenon in the East Slopes. They occur most frequently in a band to the east of the mountains throughout the entire area, decreasing in frequency

from south to north and from west to east[2]. They are especially pronounced in gaps like the Crowsnest Pass, Bow Valley and Athabasca Valley.

Chinooks are most frequent and noticeable in fall and winter months, but occur throughout the year. They may fail to occur in winter approximately one year out of ten. Frequency usually varies from 5 to 40 per year but local variations are great and reliable information on frequency and duration of chinooks can only be obtained by detailed local study.

Chinooks are characterized by a sharp rise in temperature - up to 40°F in 5 minutes is not unusual - and strong gusty westerly to southwesterly winds, usually 25 to 50 miles per hour but frequently 60 to 80 and sometimes in excess of 100 miles per hour.

Chinooks are usually associated with cyclonic activity which produces clouds and precipitation on the windward side of the mountains. As the air passes over the mountain barrier from west to east, mountain waves develop and the air descends on the leeward side of the mountains. The air is heated adiabatically 5.4°F for every thousand feet drop in altitude, warming by compression, and becomes very dry.

Chinooks bring periods of warmth during cold winter months which benefit domestic livestock and wildlife both through the temperature effect and by removing snow to improve grazing conditions.

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[2] Longley, R.W. 1967, The frequency of winter chinooks in Alberta. Environ. 5(4):4-16.

Adverse effects include sublimation and evaporation, which depletes snow and water storage, soil erosion and possibly range damage, as well as power line damage and structural damage to buildings. Trees may be wind-thrown and fire hazard increased; desiccation may reduce tree growth, and the widespread phenomenon of "red belt" in trees, particularly lodgepole pine, may be partly due to chinook conditions[3].

Chinook winds have special implications for planning buildings and roads in the East Slopes, and should be given special consideration when selecting sites for snow-dependent facilities such as ski hills. They also have significance for dispersion of industrial air pollutants, as shown in a following section.

2c) PRECIPITATION

Over most of the prairies, the mean annual precipitation ranges from 10 to 20 inches whereas in the East Slopes the mean annual precipitation increases from about 18 inches on the eastern boundary to more than 60 inches in some portions of the frontal ranges. The mean precipitation is extremely variable in this area, depending both on elevation and on position relative to the mountains, but there is little variation with latitude. Since the evaporation in the area is normally less than 7 inches, the large precipitation input results in substantial runoff. Hence this area is the source for most of the rivers flowing across the prairies.

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[3] Recent large-scale occurrences of red belt in the East Slopes is currently being investigated by the Department of the Environment of Canada Northern Forest Research Centre, Edmonton.

The mean annual snowfall in the region ranges from 60 inches to over 200 inches as compared to 30 to 60 inches for the prairies. These large snowfalls combined with warmer wintertime temperatures than those experienced on the prairies (mean January temperatures of 10 to 20°F) make the East Slopes region ideal for winter recreational use.

When large rainstorms occur in southern Alberta, the rainfall amounts in the western regions are usually larger because of the lifting of the air by the mountains. This orographic lifting, which is usually associated with easterly winds, causes the heaviest rainfalls to occur along the line of the most easterly range of mountains. The largest rainfalls over large areas generally result from disturbances originating over the Pacific Ocean and moving eastward across the mountains. These storms can occur in the most southern or northern portions of the region with similar intensities. The most significant large rainfall for this area occurred west of Claresholm on June 28-30, 1963, and yielded 8 inches of precipitation in 48 hours when averaged over 500 square miles.

2d) AIR POLLUTION POTENTIAL

Wind direction and speed, turbulence and stability have the most important influence on the diffusion of pollutants in the atmosphere. Several factors contribute to air pollution potential. The height of the layer in which pollutants are diluted by vertical mixing (the "mixing height") and the strength of the mean wind within this layer are two such factors. The product of the mixing height and mean advective wind determine the "ventilation" characteristics in the boundary layer of the atmosphere. The duration of stagnation or poor ventilation conditions

must be defined to determine the air pollution potential. It should be noted that high pollution potential must be combined with a large input of pollutants to cause high pollution concentrations.

The duration and extent of high air pollution potential conditions have not been determined for the East Slopes Region. The lack of meteorological observations suitable for a proper air pollution analysis certainly limits the scope of such studies. However, a recent study points out that the valleys of the Cordillera and the East Slopes have frequent occurrences of light winds relative to the Prairies.[4] The spatial and seasonal variations in persistent light winds suggest that, in the mountain and foothill valleys topography is the major factor while in other regions synoptic weather patterns are more important. Duration of stagnation periods or persistence of light winds is at a minimum in spring and increases to a maximum in winter. The isopleth depicting about 4 occurrences per month for winds 3 meters per second or less persisting 24 to 47 hours expands sevenfold in area from spring to winter and advances eastward over Alberta as winter approaches.

A recent climatological study delineates patterns of night-time inversion frequencies in Canada.[5] It shows a slight maximum extending from Montana through Edmonton to Ft. Nelson. This zone of high frequencies is most pronounced in winter but is a consistent feature in other seasons.

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[4] Shaw, R.W., Hirt, M.S. and Tilley, M.A. 1972. Persistence of Light Surface Winds in Canada; Atmosphere, Vol. 10, No. 2, 1972.

[5] Munn, R.E. Tomlain, J., Titus, R.L. 1970. A Preliminary Climatology of Ground-Based Inversions in Canada; Atmosphere, Vol. 8, No. 2, 1970.

Studies to date show that the East Slopes is an area of high air pollution potential especially in narrow north-south valleys with poor drainage and in any valley that experiences infrequent Chinooks. The most serious potential conditions occur during cold seasons when a stagnant continental Arctic air mass lies over the region. Cold air becomes trapped in valleys, inversions are intensified either by radiational cooling under clear skies or alternately by warm air advection over the Arctic air mass, subsidence due to mountain waves or by migrating upper anticyclonic patterns.

Conditions are on occasion similar to those in the Columbia River Valley.[6] At times, pollution may drift up and down the valley over a 24-hour period with very little net transport. Under such conditions a stack source designed according to "ideal" (steady wind and long uniform fetch) conditions could create ground level concentrations of pollutants well above maximum allowable levels. Limited mixing, fumigation and topography mitigate against proper stack height design for valley locations.

The Chinook is a mixed blessing. It gives maximum ventilation where it reaches ground level. However pockets of cold air are often trapped or skipped and the ambient inversion in the cold air is intensified.

Patterns of ground level concentrations of pollutants from sources on the East Slopes is no doubt complex due to the variety of

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[6] Hewson, E.W., 1945. The Meteorological Control of Atmospheric Pollution of Heavy Industry, Quart. Jr. Met. Soc. 71, 266-282.

meteorological conditions experienced in the area. The effects of topography compound the problem, and land use planners should take special precaution when considering a chimney height design study in mountainous or foothills terrain.[7] An experienced air pollution meteorologist or local meteorologist should be consulted for information on regional and local weather patterns.

D3. USE OF METEOROLOGICAL INFORMATION IN LAND USE PLANNING

It is important to recognize that there are three levels of approach in planning- macro-, meso- and micro-scale. The type of meteorological information required varies largely with the planning scale.

Macro-scale planning can take cognizance of the existing meteorological observing network in which first order stations measuring a wide range of parameters on an hourly basis are spaced 100 - 200 miles apart. Climatological stations which report measurements of temperature and precipitation twice daily are situated on a grid size of approsimately 25 miles, and frequently will show meso-scale atmospheric processes.

It is also possible to obtain information on the meso-scale from an historical survey of network data, incorporating information provided by stations now closed, with adjustments for climatic change where applicable. In such a study, particular attention is paid to site conditions surrounding the station and an estimation of the

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[7] Scorer, R. S., 1968. Air Pollution Problems at a Proposed Merseyside Chemical Fertilizer Plant. A Case Study. Atmos. Envir. 2, 35-48.

representativeness of the station for the region is made. In regions where the network is sparse, but roadways exist, a mobile survey can establish relative changes in temperature, humidity and wind as the topography or vegetation varies. In other areas less accurate aerial surveys and recording mechanical weather stations can be used. Short period radiosonde flights may be useful in many cases.

For micro-scale or site planning, special stations and surveys including vertical surveys are required. Data such as that for Marmot Creek Basin are required for proper site planning. Each site plan requires independent consideration and extensive consultation with specialists of other environmental disciplines.

Where the environment is especially complicated and it is important to separate causes from effects the use of simulation modelling is recommended. Preliminary boundary conditions can be derived without great difficulty though it is fair to say that greater precision requires considerable experimentation. In recreational studies, we have made recent advances in establishing boundary conditions for seasonal activities, and similarly, air pollution, meteorological and other physical data may be modelled and first approximation land use plans derived.

Appendix III describes common meteorological parameters and methods for their expression suitable for land use planning. Other parameters measured at principal meteorological stations such as cloud height and cloud types, visibility, and special phenomena (e.g. blowing snow) may be useful information in site selection.

In addition, there are special problems and procedures which require particular attention in the East Slopes. The Chinook has a marked effect on life in western Alberta, and much has been written about it and similar features in other parts of the world. Yet, little is known of its structure from place to place at a particular time. Wintertime flights over an affected area have shown elongated streaks of snow removal while other nearby areas are largely unaffected. Clearly, maximization of effects, and transposition of these data to other potential areas would be a useful beginning.

Notwithstanding a lack of measured data, topographic forms which are likely to be still air zones should be avoided by industry and overnight camping, for reasons of pollution entrapment, anomalous cold and inferior ventilation. Moreover, pollution and heat sources should not be located upwind from existing or proposed settlements.

D4. USE OF METEOROLOGICAL DATA IN URBAN PLANNING

Good planning can utilize precipitation studies to avoid costly overexpenditures in the required sewer systems. Snowdrifting studies combining snow data and associated wind can avoid the creation of unnecessary snow removal costs by anticipating problems created by ill-advised locations of building and other snow accumulators. Snowdrifting studies can avoid costly repairs to buildings and costly overdesign by eliminating unnecessary snow receptacles in the design stage. Cutting tree groves may solve or create a snowdrift problem and ill-advised planting for aesthetic purposes may well create a snow accumulation problem in a roadway or an entrance to a building.

Some general comments on the usefulness of climatological data and their limitations are appropriate:

1) It could well be that most of the available climatological data is peculiarly unsuited to application in the East Slopes. One obvious statistic that comes to mind is one of inversion heights. Radiosonde data are obtained at Fort Nelson, Edmonton, Great Falls, and during some summer months, Rocky Mountain House and Calgary. The valley, hill and mountain areas to the west of these radiosonde stations are an entirely new set of environments. The same could be said for wind statistics. Precipitation has been studied on a more localized scale within the East Slopes area but certainly not on an extensive enough scale to determine the many and varied climatic regimes and sufficient detail to make an intelligent master plan of the area.

2) When a development project is suggested, and before approval is given, the area should be studied by a team of experts including meteorologists It would be too costly to instrument the entire East Slopes area to obtain the meteorological information required to anticipate and solve all problems that might arise. It would be largely wasted effort because the greater part of the area may never be developed in any case. However, the absence of specific, applicable, meteorological information in a proposed development area should not be sufficient excuse for proceedings without regard to the hazards involved. Once a specific development area is recognized, then meteorological instrumentation and expertise should be obtained before approval is given. This meteorological information should be considered by and made an integral part of each step in the location and development of the site.

E. THE WATER RESOURCES OF THE EAST SLOPES

E1. IMPLICATIONS OF USE AND MANAGEMENT

In managing the water resources of the East Slopes of the Rocky Mountains consideration must be given to the impact this will have on the much larger region beyond the boundaries of the management area. This larger region is defined by the Saskatchewan-Nelson River systems in the south and the Mackenzie River system in the north. Of the five watersheds defined for the hearings, the three more southerly, the Oldman, the Bow and the North Saskatchewan, are major headwaters of the Saskatchewan-Nelson River systems; the two more northerly, the Athabasca and the Smoky, are significant headwaters of the Mackenzie River system.

In the sense of using resources in their natural state, the water resources of the East Slopes differ from the land, forest, wildlife and mineral resources in the area. The land, forests, minerals, and to a lesser extent the wildlife resources, are static in terms of location and the "first" use of these resources is in situ: the water resources are dynamic in terms of location and the "first" use of this resource may be at any point on the Saskatchewan-Nelson or Mackenzie River systems. Streamflow that originates in the East Slopes area is used for municipal and industrial water supply, recreation, wildlife habitat, agriculture, hydro-electric power and navigation in this larger region.

At least to the extent that it affects streamflow, management of the resources of East Slopes area has an impact in the three Prairie Provinces and in the Northwest Territories.

E2. INTERPROVINCIAL SYSTEMS

Recognition of the regional importance of streamflow in the Prairie Region is manifest in the Master Agreement on Apportionment by which Canada, Alberta, Saskatchewan and Manitoba agree to apportion the flow of interprovincial streams in the Prairie Provinces, and by which the Prairie Provinces Water Board has been established to administer the agreement. In general terms, the Apportionment Agreement permits Alberta to consume 50 per cent of the natural flow of a river before it enters Saskatchewan; Saskatchewan may consume 50 per cent of the flow entering the province from Alberta and 50 percent of the additional flow rising within its boundaries; and Manitoba receives the remainder.

The Prairie Provinces Water Board is presently undertaking studies to determine the best way to calculate natural flows and the data collection network necessary to provide the information for these calculations. These studies are also concerned with streamflow forecasting with respect to both long term forecasts of volume and short term forecasts of floods.

The Master Apportionment Agreement also concerns the quality of water in interprovincial streams to the extent that the parties to the agreement have agreed to monitor water quality, refer water quality

problems to the Prairie Provinces Water Board and to consider recommendations from the Board arising from such referrals. While water quality standards common to the three provinces do not exist, the provinces have agreed in principle to the adoption of water quality objectives which are essentially similar for each province.

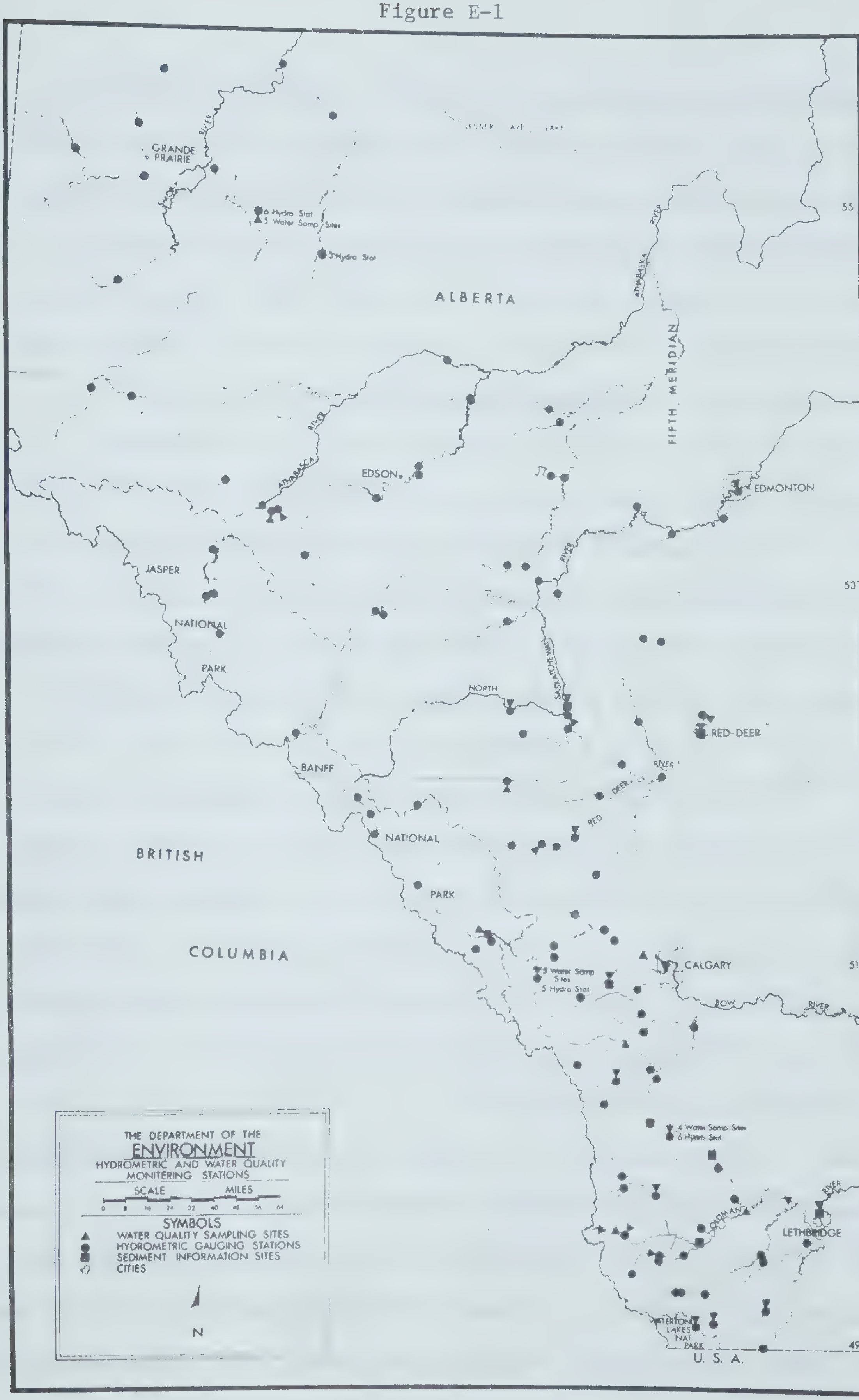
At present no water management agreements exist for streams which flow north into the Mackenzie River system. It is possible, however, that an agreement similar to the approtionment agreement for prairie streams may be developed in the future.

E3. WATER DATA NETWORKS

Streamflow gauging in the East Slopes region is conducted by the Department of the Environment of Canada under agreement with the Province of Alberta. A total of some 80 gauging stations are operated directly within the East Slopes area while another 30 sites are gauged in the near vicinity. The locations of these gauging stations are indicated in Figure E-1. In addition, a large number of gauges are operated at sites far removed from the East Slopes but which are on streams that derive the greatest percentage of their flow from the East Slopes. The data from these are used to complement the gauging station network in the assessment of available water supply and streamflow forecasting.

The streamflow monitoring program provides an inventory of the available water resources within the East Slopes. It indicates

Figure E-1


GRANDE PRAIRIE
RIVER
6 Hydro Stat
5 Water Samp Sites
3 Hydro Stat
ALBERTA
ATHABASKA RIVER
FIFTH MERIDIAN
55
EDSON
ATHABASCA RIVER
EDMONTON
JASPER
NATIONAL
PARK
53
SASKATCHEWAN RIVER
NORTH
RED DEER
RED DEER RIVER
BANFF
NATIONAL
PARK
BRITISH
COLUMBIA
CALGARY
51
5 Water Samp Sites
5 Hydro Stat.
BOW RIVER
4 Water Samp Sites
6 Hydro Stat
OLDMAN
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LETHBRIDGE
WATERTON LAKES NAT PARK
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THE DEPARTMENT OF THE
ENVIRONMENT
HYDROMETRIC AND WATER QUALITY
MONITERING STATIONS
SCALE MILES
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WATER QUALITY SAMPLING SITES
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the availability of water supplies within each region or basin and is useful in the design of structures located on, or crossing, rivers and streams. Peak flow information is invaluable in the design of culvert and bridge crossings and in the site selection of camp shelters and recreational areas. The availability of water is a limiting factor in the location of industrial plants. If only a small amount of water is available within a basin it will preclude the location of industries which require large volumes of water for processing or for sewage treatment and disposal.

The Department of the Environment of Canada undertakes the systematic measurement of sediment discharge on some streams in the East Slopes. The sediment network is much smaller than the hydrometric network; only 12 sites within the area are monitored for sediment discharge. These sites are shown in Figure E-1.

Water quality information on the East Slopes dates back to 1963. The information accumulated is for an area extending from the Oldman River drainage basin in the south to the Athabasca River drainage basin in the north and includes the Streeter, Marmot, Deer Creek and Tri-Creek Research Basins. In addition, 13 stations on the headwaters of streams of the Saskatchewan River system are monitored. The locations of these are shown in Figure E-1.

The characteristics of these streams dictate a varied sampling frequency which ranges from twice weekly in the spring and early summer to once every two months during the winter. To adequately determine changes which may occur as a result of further development in this area, the number and location of sampling points would have to be reviewed and

revised depending upon the location and size of any particular development, and the frequency of sampling and the parameters to be measured probably increased depending on the type of development. Currently, all samples are being analyzed for major ions, physical parameters and seasonally, for heavy metals.

E4. SOME MAJOR CONSIDERATIONS

4a) WATER STORAGE AND DIVERSION

Extensive studies have been completed or are at present under way concerning the potential demand for, and supply of, water in the Prairie region. The federal-provincial Saskatchewan-Nelson Basin Board investigated the potential for large scale water development projects in the East Slopes area. If, in future years, the need for greater supplies of water in the Prairie region materializes, it may be necessary to develop some of this potential. Before decisions are made to develop any of these storage or diversion projects, much more must be known about their potential environmental impact. A program to obtain background information to provide an understanding of the physical, chemical and biological processes involved and their probable effects on life systems should be initiated now to facilitate a proper assessment of environmental impact.

The Prairie Provinces Water Board is embarking upon a study of water use in the Prairie region which may lead to efforts to determine future water needs in the region.

4b) SEDIMENT LOAD

Any modification to a stream channel or to its drainage basin can result in a change in the volume of sediment transport of the stream. Modifications to the stream channel itself which increase the transportability of the stream would result in accelerated rates of stream bed and channel erosion. Conversely, modifications which decrease the energy of the stream result in deposition and sedimentation.

Modifications to the drainage basin affect the availability of sediment particles. An increase in the amount of sediment particles might result in immediate deposition at their points of entry to the stream, or if excess energy were available, then the particles would carry downstream to some point where the energy would be less than required to transport the total sediment load, resulting in deposition at that point. If basin modifications decrease the amount of available sediment particules, then the stream will generally have an excessive amount of energy resulting in an increased potential for degradation and side-cutting.

4c) SEDIMENT LOAD CHANGES DUE TO RESERVOIR CONSTRUCTION

Reservoirs act as stilling basins which drop out all or most of the sediment carried by the stream. The deposition not only occurs directly within the reservoir area, but also can occur for some distance upstream of the reservoir due to backwater effect. A delta will form at the upstream end of the reservoir. Because of the swampy nature of a delta it can often be unsightly. Upstream deposition can reduce the channel capacity which would have the effect of increasing the frequency of overbank flooding.

Immediately downstream of the reservoir an accelerated rate of degradation will be experienced due to the availability of excessive energy. The reservoir will modify the flow regime and thus major deposition may occur downstream of the junctions of large tributaries. This comes about because of the reduction in peak flows which correspondingly reduce the carrying and/or flushing capacity of the stream.

4d) SEDIMENT LOAD CHANGES DUE TO BASIN DEVELOPMENT

Basin development will affect the sediment particle availability to the stream and can also affect the streamflow runoff pattern which, in turn, controls the amount of sediment being discharged.

Any type of basin development normally requires that additional roads be constructed with their resultant stream crossings. These crossings, whether of the culvert, bridge or simple fording type, will increase the amount of sediment available to the stream. In addition, the basin development itself, whether for a recreational area complex, mining operation or simple camp shelter, may increase the availability of erodable material.

Large-scale operations within the basin such as logging or strip-mining will not only affect the sediment particle availability, but may also change the runoff patterns. For instance, peak flows might be altered considerably. Since the greatest portion of sediment is carried during peak flow events, the quantity of transported sediment can be greatly affected. The timing of the peak flow events may also be altered so that the peaks may occur at a time when the soil particles are still frozen, thus inhibiting erosion.

In any event, all developments within a basin, whether large or small, should be investigated to determine their possible effects on the stream near the development and the effects these developments might have on the stream at sites far removed from the actual development.

4e) WATER QUALITY

The composition of natural surface water is greatly influenced by inorganic and biochemical processes.

The inorganic processes controlling natural water composition and their relative importance in any one environment are controlled by factors such as climate, geology, soils, precipitation, and the hydrologic cycle.

The biological factors which control biochemical processes are important in almost all aspects of natural water composition. Biological factors and processes are so interrelated in bringing about the composition of water that, in any sense, natural water composition cannot be studied without involving the concepts of ecology. As in ecologic systems, changes in one factor may bring about a considerable number of other changes that can influence the variable being observed.

The life processes of particular interest in the quality of water are: 1) photosyntheses, 2) metabolism and decay, 3) biochemical reduction and oxidation, 4) stabilization of inorganic colloids by soluble organic matter, and 5) the release of biological

waste products.

Life forms and the chemical processes associated with them are intimately related to water and to the solutes contained in water. Therefore, maintaining (or preserving) a good quality of water is critical to the maintenance of proper balance among the diversity of life forms.

Activities that cause increased erosion can drastically alter the suspended solid, turbidity, color, organic matter, carbon, nitrogen, phosphorus, sodium, potassium, chloride, and minor element content of streams.

Disturbance of natural vegetation and the removal of forests can profoundly alter the chemical composition of water in streams by increasing the organic carbon, nitrogen and organic phosphate content, and can lead to undesirable increases in water temperature in the headwaters.

All streams and particularly lakes or impoundments in downstream reaches are vulnerable to accelerated eutrophication and, therefore, must be protected from critical concentrations of carbon, nitrogen, and phosphorus that can leach from surrounding disturbed land and cause excessive acquatic plant growth and algal blooms.

Of major importance is the effect such changes in water composition can impose on downstream or local use of water for recreation, fish and wildlife, agriculture, or human consumption.

Water quality monitoring and control programs are an important and integral part of environmental protection during any activities in the East Slopes area.

F. WATERSHED MANAGEMENT IN THE EAST SLOPES

F1. MANAGEMENT OBJECTIVES

All land upon which precipitation falls is watershed, including groundwater recharge areas as well as surface runoff areas which have obvious drainage systems. Also, all watershed is amenable to management for purposes of controlling the amount, timing and quality of the water yield. This includes both forested and non-forested lands.

All areas of the East Slopes do not need to receive the same intensity of management to maintain their existing watershed role. But they all need some management to prevent negative benefits to the water supply and/or to allow near or distant future manipulation should it become desirable. It is essential that one or more of the following management objectives be applied in the East Slopes.

1a) WATERSHED PROTECTION

Protection is essential to keep the land forested. This is by no means a passive role. Some active silviculture is essential to maintain a healthy forest. The timber in buffer strips adjacent to stream channels and in areas above 6500 ft. elevation will gradually deteriorate from age if steps are not taken to renew it. However, the steps taken should not include clearcutting as is now the case, because the time required for replacement by a similar sized forest to allow future purposeful watershed manipulation will optimistically be 50 to 100 years. Protection from destruction by insects, disease or fire is taken for granted.

1b) WATERSHED "CONSIDERATIONS"

This implies that other product uses such as wood, wildlife, recreation or grazing may be important existing or potential uses on an area from which quantity, quality and timing of streamflow are important, but need not be optimized. An example would be the watershed area for a reservoir. The structure itself would control streamflow quantities and timing below its outlet, but it would be undesirable to have the active life of a reservoir reduced by unnecessary sedimentation. In this case, consideration should be given to the effects of developments and operations in the watershed upon sedimentation.

1c) PURPOSEFUL WATERSHED MANIPULATION

Purposeful watershed manipulation should be exercised where and when the production of water is the primary use of the land area. Land use plans would be directed toward optimizing some portion or portions of the hydrograph and/or quality of the water yield. Other land uses would receive "consideration" but not optimization. Land management to this degree is a viable means of augmenting water supply in the East Slopes and should be given consideration in conjunction with or as alternatives to engineering works for the same purpose.

The potential for water yield manipulation through timber harvest in the East Slopes is high. The land area from which the major portion of the annual flow in the Saskatchewan, Athabasca, and Smoky river systems originates is small compared to the area served by the water. In the case of the Saskatchewan drainage, the figure commonly quoted is that 90 per cent of the runoff comes from 16 percent of the land, which is an approximately correct apportionment. It is likely that

a similar apportionment would hold for the Athabasca and Smoky drainages as well. Thus a large area benefits from management on a small proportion of that area.

The historical research base for water yield alteration in climatic-vegetative-topographic situations similar to the East Slopes indicates a high probability of success in altering water yields in the East Slopes. <u>Results from harvesting experimental catchments in lodgepole pine and mixed spruce-fir watersheds where snow is a major source of streamflow indicate increased yields of 20 to 50 percent</u>, depending upon normal yield and type of harvest accomplished. The climatic extremes of Colorado and Arizona where these experiments were performed encompass those found in Alberta. Therefore <u>similar results should be expected in the East Slopes</u>.

The similarity of results in the East Slopes to those elsewhere is the subject of tests currently being conducted by the Department of the Environment of Canada within the Alberta Watershed Research Program. A commercial clearcut is to be tested in Marmot Experimental Watershed, Cabin Creek sub-basin, starting in 1973. It is expected that this test will verify the general statement that timber removal increases streamflow. It is also expected to be indicative of the magnitude of the effect from similar high altitude apruce-fir forests harvested elsewhere in Alberta. Preliminary results from this test will be available in 1976.

Of more far-reaching consequence is the program in hydrological simulation modeling. Studies currently under way are expected

to yield computer models relating land use patterns to water yield in both quantity and time. Such models will allow simulation of land use activities for evaluation before they become actualities "on the ground". Preliminary tests of such models on Marmot Creek indicate a high probability of success. The commercial harvest on the Cabin Creek sub-basin will be simulated to test streamflow against actual streamflow after harvest. These and similar tests planned or anticipated elsewhere throughout the East Slopes will provide positive watershed harvesting-systems guidelines for purposeful hydrograph manipulation.

F2. REASONS FOR PRACTISING WATERSHED MANAGEMENT IN THE EAST SLOPES

Watershed management is needed to maintain the yield and quality of water in the East Slopes. There are some seasonal water shortage problems and in some cases water quality problems in areas served by East Slopes water that are amenable to partial solution through headwater management. However, for the most part, what is needed is the assurance that land uses capable of causing damage to water quality or regime will not be imposed upon the East Slopes. This means that either "protective" or "consideration" management should be practised. At present, some areas of the East Slopes, namely portions of the Rocky Mountains Forest Reserve[1] are

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[1] An area of the East Slopes south of the Brazeau River, designated in 1947 as a prime area for watershed protection and, until March 1973, having special status under the Eastern Rockies Forest Conservation Act of 1948.

under protective management. However, others are being managed without real consideration for the watershed values they possess.

Purposeful watershed management should be considered as an alternative or complement to water projects planned around diversions from one river basin into another. Table F-1 indicates the yield increases that have been recorded from experimental forest harvests in areas outside Alberta. There is no reason to expect less effect in Alberta. The possibility of combining forest harvest with management to augment water supplies should be recognized. The probable benefits to water, added to those of the timber industry and possibly wildlife or recreation, and the long-lasting effects of such management in Alberta (likely greater than 40 years) in altering runoff should make such schemes economically competitive with engineering works. Watershed manipulation schemes can be made labor intensive too: an added benefit at times of high unemployment, especially so because the work can be spread over a number of years.

Lastly, watershed management should be conducted to prevent the occurrence of dis-benefits. The northward and eastward-flowing rivers of the Prairies are normally flood prone. In the northern part of the region snowmelt may occur in the headwaters simultaneously with or prior to ice breakup further downstream. We know that certain forestry practices encourage early snowmelt and subsequently early runoff. The critical position of the East Slopes in supplying the majority of runoff in the Prairies and Boreal river systems makes it mandatory that these headwaters are not mismanaged to create even greater flood hazard.

TABLE F-1

ANNUAL RUNOFF AS A PERCENTAGE OF ANNUAL PRECIPITATION

Watershed			Not Harvested	Harvested
1.	Coweeta 13(1940)	North Carolina	43%	64%
2.	Coweeta 13(1962)	North Carolina	43	64
3.	Coweeta 3	North Carolina	33	40
4.	Coweeta 22	North Carolina	62	71
5.	Fernow 1	West Virginia	38	47
6.	Fernow 2	West Virginia	44	48
7.	Fernow 7	West Virginia	54	60
8.	Wagon Wheel Gap	Colorado	29	36
9.	Fool Creek	Colorado	37	48
10.	Kamakia	East Africa	28	51
11.	Kenya	East Africa	22	27
			39.36	50.54

F3. WATER MANAGEMENT POSSIBILITIES THROUGH WATERSHED MANAGEMENT IN THE EAST SLOPES

The present pattern of water yield in 5 Foothill zones is indicated in Table F-2. The zones are not divided on a watershed basis, so there is some overlap of data between them in the tabulation.

The demand for water from each zone is not uniform. The highest demand is for water from zone 1. This zone supports an irrigated farming economy around Lethbridge-Taber. The present flow is almost completely allocated and any further expansion would have to be accompanied by more efficient water use, or increased supplies.

Zone 2 is in somewhat better shape except in very low run-off years. The City of Calgary draws its municipal water supply from the Elbow River. However, most municipal water use is non-consumptive; approximately 70 per cent of the water withdrawn is returned to the Bow River, its quality somewhat impaired. Water quality in the Bow River may be reduced if the streamflow is insufficient to assimilate the effluent return flow.

Zones 3, 4 and 5 have adequate to more than adequate supplies of water. The principal problem in these zones is poor time distribution rather than low overall quantities. Zone 3 may suffer from water quality problems downstream from Edmonton if sufficient flows are not present to dilute any returned water.

The probable changes that could be effected within any of these zones is related to the total water yield, timing of yield, and the vegetative - topotraphic configuration of the watershed. Table

TABLE F-2. Water yield from selected watersheds in the East Slopes.[1]

River	Station name	Watershed area mi²	Mean Discharge cfs	Mean yield inches
Zone 1. Oldman River Basin				
Oldman	Lethbridge	6,640	3,290	6.7
Willow Creek	Claresholm	446	130	4.0
Oldman	Waldron's Corner	551	500	12.3
Castle	Beaver Mines	319	609	25.9
Waterton	Waterton Park	733	673	32.3
Zone 2. Bow River Basin				
Bow	Composite	5,005	4,403	11.9
Highwood	Diebel's Ranch	300	470	14.3
Elbow	Bragg Creek	306	405	12.1
Marmot	Main	3.6	4.41	16.5
Marmot	Cirqua	0.44	0.95	29.4
Zone 3. North Saskatchewan				
N. Sask.	Rocky Mtn.Hse.	4,220	5,090	16.4
Prairie Creek	Rocky Mtn.Hse.	318	165	7.1
Mistaya Creek	Sask.Crossing	94	235.3	34
Zone 4. Athabasca River Basin				
Athabasca	Hinton	4,000	6,600	22.6
McLeod	Wolf Creek	2,510	1,320	7.2
Pembina	Paddy Creek	1,110	756	6.2
Wildhay	Trunk Road	373	392	14.2
Tri-Creeks	Composite	23.2	14.1	8.2
Zone 5. Smoky River Basin				
Smoky	Watino	18,500	13,200	9.7
Little Smoky	Guy	4,130	1,920	6.3
Smoky	Hells Creek	1,480	3,313	30.4
Wapiti	Grande Prairie	4,350	3,750	11.7
Little Smoky	Little Smoky	1,170	502	5.8
Waskahigan	Mouth	402	174	5.8

[1]Data from Neil, C.R. et al. 1970. Selected characteristics of streamflow in Alberta, Research Council of Alberta, River Engineering and Surface Hydrology Report 70-1: and streamflow records for selected periods from Canada Department of Environment, Water Survey of Canada.

F-3 gives the timber and alpine areas within each zone that are reasonably available to manage as watershed and the water yield from each.

The potential for yield manipulation within each Foothills zone depends upon the current vegetation and water yield of that zone. The Alpine-Krumholz zone is a high water-yielder, but has little vegetation to manipulate. Some augmentation of late season yield may be possible by creating local snow "sinks" through snow fencing, arrangement of existing Krumholz, selective plantings, or avalanching. The techniques to accomplish these ends are being evaluated in similar areas of the Rocky Mountains in Colorado. Also a great deal of avalanche research is being conducted by the National Research Council - highways research group - in Canada. In general, an extra foot of snow added to high elevation snow fields will result in an additional week's runoff from that field. There is apparently no current inventory of such snow fields for the East Slopes, and hence no way to evaluate the overall effect such management might have on the water supply.

The vegetative zone of most importance in watershed manipulation is the Spruce-Fir zone that occurs at an elevation just below the alpine. Much of the winter's snow pack that accumulates on any watershed occurs here. Some snow is blown from bare alpine areas into this zone. Often snow remains along tree margins or in topographic depressions long after the general snow pack has melted. It therefore has the highest management potential for augmenting total flow, and except for alpine snow fields, is the only area with management potential for augmenting late season flow. At present watershed management experts know how to

TABLE F-3. Distribution of timbered and alpine areas in Forest Reserve[1].

Type	Area square miles	c/o reserve	Water yield inches
Alpine-Krumholz[2]	2,813	31.2	15-30
Spruce-fir[2]	658	7.4	12-20
Pine-spruce[2]	1,602	17.9	7-12
Pine[3]	2,198	24.5	5-10
Deciduous[4]	1,682	19.0	0-5

[1] Water yield for each zone estimated from experimental basin data.

[2] Based on Marmot Experimental Watershed data.

[3] Based on Tri-Creeks Experimental Watershed Data.

[4] Based on Spring Creek Experimental Watershed Data.

get from 20 to 30 percent more water from this zone. The increased yields are added to the rising limb of the snow melt hydrograph, and are apparently very long-lived (up to 40 years) as they are dependent upon residual stand aerodynomics more than reduced evaporation loss. We do not know if it is possible to manipulate this same vegetation to delay snowmelt runoff. Studies are under way at the Northern Forest Research Centre to determine how snow melt may be hastened or delayed by forest manipulation in the Marmot Experimental Watershed near Kananaskis and the James River area west of Sundre, Alberta. These studies are expected to provide harvesting guidelines for subsequent watershed tests at Marmot Creek in 1976-78.

Notwithstanding the results of these tests, our present knowledge indicates that clearcutting of high altitude Spruce-Fir forests creates water yield at a time when it is either of no use, or detrimental to downstream water users. All harvesting in this zone except perhaps very selective maintenance cuts, should be curtailed until the positive, purposeful watershed harvesting plans originally envisioned by the Eastern Rockies Forest Conservation Board in their requests for and support of watershed research, can be generated and tested.

The Spruce-Pine zone is an intermediate water-yielder. The manipulation potential is still high for increasing overall water yield. This is a small area and should be attached to the Spruce-Fir zone for the purpose of watershed management. Probable annual yield increases of 20 to 30 percent are likely.

The Pine zone occupies the largest land area in the East Slopes and in the northern foothills is under intensive forest management now. Snow melt runoff accounts for a lower percentage of the annual runoff from this zone than from the previous three. Elevation gradients within this zone are low and the amount of overland, (surface) flow from snow melt is small. It receives more local thunderstorm activity than the three preceding zones. From the watershed standpoint, it should be managed to increase local groundwater recharge and reduce sediment inflow to the streams. Patterned clearcutting of forests could accomplish both of these objectives if watershed manipulation were given "consideration" in the cutting plans. This kind of cutting would probably improve big-game habitat as well. Some late-season flow augmentation may be possible. However, the most important runoff to manipulate is that originating from local storms. Peak flow increases of 500 percent have been reported elsewhere following clearcutting. Changes of this magnitude are generally short-lived, decreasing rapidly upon revegetation. Therefore, it is important to control the percentage of the land actually clearcut over a given time period in any critical watershed (such as that supplying a city, or a railroad crossing) to prevent unplanned peak flows that will cause damage.

The Deciduous zone is the least important in the East Slopes in terms of water yield. On-site and local water requirements ought to determine the management it receives. Since its yield to stream flow is small, watershed management can be accommodated on ad hoc "consideration" basis in each local situation.

F4. PLANNING FOR A DESIRABLE WATER PRODUCT FROM THE EAST SLOPES

Any increase in water yield as a result of accidental or incidental watershed management will, at best, be useful only as a fortunate happenstance. It is an established fact that land management activities such as forest harvesting influence water yields. Such management activities applied to land designated as a watershed should be planned to enhance the usability of the water product. Land management in a designated watershed that does not include consultation with the water user may be worse than no land management at all. That is, it may be better to let the forest deteriorate in an overmature state than to manipulate it improperly and by so doing, to remove opportunities for properly planned watershed management in the future.

All land-based operations in the East Slopes and especially in the Rocky Mountains Forest Reserve, should be carefully examined with respect to their ultimate effect on water and water users, both on-site and downstream. The on-site water resource users, such as fish, recreationists, wildlife and domestic range animals are very important within the Forest Reserves. These, coupled with the interprovincial use of the Saskatchewan river water make it mandatory that water continue to be one of the most important benefits arising from these lands. This consideration should take the tangible form of management plans with watershed values as primary objectives.

Management within the entire East Slopes must be carefully planned and carried out if it is to meet user's needs in the future.

G. THE FISHERY OF THE EAST SLOPES

G1. SPORT FISHERY

The fishery of the East Slopes is almost exclusively a sport fishery, based on the native species of rainbow trout, Dolly Varden, cutthroat trout, golden trout, brown trout, Eastern brook trout and Rocky Mountain whitefish. The trout species can be maintained only if resource development is carefully designed and regulated to ensure a minimum disruption of fish habitat.

G2. WATER CONTROL

The East Slopes area has potential for hydro-electric reservoir development. The area is also a focus for recreation, both from within Alberta and from non-resident and foreign users. Pressures on the sports fishery in the East Slops are already such that stocking programs are necessary. The impact of reservoir development on fisheries and other recreational resources should be carefully considered in development plans for the area.[1]

2a) RESERVOIRS

Reservoirs can be highly beneficial to recreation as they facilitate a number of important water-based recreational activities such as boating, fishing, camping, and swimming. However, these activities can be established and maintained only by careful

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[1] Snipe, J.H. 1970. The ecological and economic impact of water resources Development in Southern Alberta: The case of Fish and wildlife. Res. Rep. No. 8. Alberta Department of Lands and Forests.

regulation of the reservoir.

When reservoirs are developed on headwaters the downstream area relies heavily on water control within the impoundment. To maintain or improve the fisheries in Alberta certain considerations are necessary in planning and using reservoir waters, such as: minimized downstream fluctuation, guaranteed minimum flows, optimal reservoir level for shoreline use, and assured public access. In some cases hydro developments may actually increase the poundage of fish available to anglers, but other factors involved with sport fishing must still be considered, particularly the differences in appeal between mountain stream fishing and reservoir fishing.

2b) DOWNSTREAM EFFECTS

The construction of dams and the creation of reservoirs imposes a physical barrier to upstream migration of fish, alters the natural cycle of stream discharge and may greatly affect the quality and quantity of water discharged downstream. Fish-spawning runs that may be disrupted by the location or design of a dam should be considered. If important trout spawning areas are located downstream from the dam, sustained recruitment and production of important sport fish such as trout and Rocky Mountain whitefish can be guaranteed only if minimum stream discharges are maintained at critical times of the year. This is necessary to ensure that adults are able to migrate to and from the spawning grounds, that the spawning grounds are adequately watered to ensure successful spawning, egg incubation and hatching, and that adequate flows are maintained for the successful rearing and

migration of young fish. Maximum flows should also be controlled or the spawning grounds may be too deep for successful spawning, or water velocities may be so great that eggs are dislodged from the redds.

Stabilization of flows is highly beneficial to trout production downstream. Cutthroat, rainbow and browns spawn in the spring while Rocky Mountain whitefish, brook trout and Dolly Varden spawn in the fall. To maintain maximum production of both groups, downstream discharge from reservoirs must be carefully regulated on a year-round basis.

In large reservoirs where the effect of stream currents is minimal, thermal stratification of water occurs in the summer. Surface waters become warmer and bottom waters become colder than that in inflowing stream(s). Bottom waters may become stagnant and low in oxygen. If the riparian flow downstream from the reservoir is from a high level spillgate, water temperatures downstream are likely to be too high for trout and whitefish, or their eggs and young, or the food organisms on which they depend. Low level discharge of cold and/or deoxygenated water may also have an adverse effect on production of sport fish. The controlled mixing of surface and deep waters can be used effectively to regulate downstream temperatures to favor trout production.

Diversion of significant amounts of water from a stream will result in a reduction in fish production downstream because of

the loss of stream habitat. Reduced streamflows also result in increased water temperatures. Drastic changes in natural seasonal flows owing to diversion of substantial volumes of water or to re-filling of reservoirs can adversely affect fish or the organisms upon which they rely for food.

2c) CHANNELIZATION

The typical mountain trout stream with its meanders, cut-banks, riffles and pools is excellent habitat for trout. The pools and cutbanks provide cover and rest for the trout, the riffles provide food in abundance and the variety of water velocities in the length and breadth of the stream sort the substrate to provide the proper depth and gravel size for successful spawning. However, this design is not efficient for the discharge of large volumes of water and flooding usually occurs in years of high runoff. The incidence and severity of flooding may be reduced by channelizing (straightening and deepening). Channelization greatly reduces the productive capacity of a stream for trout because the length and area of the stream are greatly reduced, velocities are too great for trout and their food organisms, and substrate formation is restricted to large cobbles and boulders in which the trout are unable to spawn successfully. A channelized stream also has a much reduced aesthetic appeal for recreation.

G3. WATER POLLUTION

The ecology and aesthetic appeal of trout streams is readily destroyed by pollution from domestic and industrial wastes.

3a) MINES

Drainage from mines and erosion of mine exploration roads, test cuts, strip or open-pit mines, spoil piles and tailing dumps is often the cause of siltation and increased turbidity in streams. This can cause physical abrasion of the gills of fish, reduce primary production and blanket and smother fish-spawning grounds and areas of the stream bottom rich in fish-food organisms.

The oxidation and solution of sulphides in mine spoils and the precipitation of sulphur from gaseous refinery emissions results in the production of acids. Unrecovered metals or toxic chemicals may be leached from tailing dumps. If carried to streams in natural runoff in large enough concentrations, fish and their food organisms may be harmed or killed.

3b) INDUSTRIAL AND DOMESTIC WASTES

The direct or indirect reception of solid, liquid and gaseous wastes from industrial and domestic sewage can have devastating effects on the ecology and aesthetic appeal of streams. Various solids may blanket the stream bottom or foul the shorelines. Unrecovered metals and chemicals may have a toxic effect on fish or their food organisms. Decomposition of organic wastes in water reduces the supply of dissolved oxygen available to fish.

Some wastes change the color of the water which limits photo-synthetic production and increases water temperature. Others impart tastes or odors to water and to fish.

G4. CONSTRUCTION

Construction projects may seriously affect the ecology and appearance of streams because of increased turbidity and sedimentation if measures to prevent soil erosion are inadequate. The construction of highways, transmission lines, pipelines and dams usually entails the removal of large areas of stabilized topsoil. The newly exposed substrate, along with the material removed as waste or landfill, is often highly erodable.

Highways and pipelines are usually located in river valleys, often on level terrain near the stream. Careful planning in construction is necessary to preserve the fishery resource and the aesthetic appeal of these rivers. Where streams are channelized fish habitat is lost. Reduction of stream bank vegetation results in increased water temperature. Modification of stream banks can reduce fish cover and increase erosion.

With increased recreational demand placed upon the East Slopes, substantial road-building and associated works such as campsites are inevitable. Mountain streams must be stringently protected by applying presently available erosion-reducing measures such as rip-rapping and re-vegetation.

The use of large amounts of highway salt and improper use of highway oil may also result in pollution of streams that receive highway runoff.

G5. FORESTRY

Improper methods of forest harvest and log transport lead to soil erosion which increases the turbidity and sedimentation of streams, with consequent adverse effects on the sport fishery. Clearcutting increases erosion because water runoff rates are accelerated. Runoff rates are also accelerated where the permeability of the soil has been reduced by compaction by logging trucks and machinery. Serious erosion may also occur where forests are removed from steep slopes or from highly erodable soils.[2,3]

The main cause of soil erosion is the disturbance of the soil surface by logging machinery, the construction of logging roads and the gouging of skid trails. Logging roads and/or skid trails are often far more numerous than necessary, poorly located (on steep slopes, in areas of highly erodable soils, on stream banks and even on stream beds), or of rudimentary construction. Highly erodable grade material may be used for temporary roads or the trail may be simply a bulldozer cut. Logging often requires stream crossings for transportation and access, which greatly reduces stream water quality. Stumps, slash and snags that are allowed to enter streams cause jams that result in bank cutting

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[2] Lantz. R.L. 1971. Guidelines for stream protection in logging operations. Oregon State Game Commission, Portland,Oregon. 29 pp.

[3] Rothwell, R.L. 1971. Watershed management guidelines for logging and road construction. Dep. Fish. Forest., Can. Forest. Serv. Inform. Report A-X-42. 78 pp.

and act as barriers to fish movement. Clear cutting of stream bank vegetation greatly reduces the aesthetic appeal of a stream, reduces fish cover, increases water temperatures and makes stream banks more susceptible to erosion. The float transport of logs on rivers disturbs the stream bed and blankets the bottom with bark and debris.

Forest insect sprays must be carefully applied because most insecticides are highly toxic to fish and their food organisms. Substantial damage to streams in other parts of Canada caused by such treatments is well documented.

The protection of forests from fires is of great importance to the sport fishery. Soil erosion is always greatly increased following forest fires and retention of water by the soil may be reduced so that total and seasonal discharge to the streams is drastically modified.

G6. PUBLIC ACCESS

One or two boat-launching areas may ensure public access to all of a lake or reservoir, but most of the fisheries on the East Slope are stream-based and access is required at regular intervals if the stream is to be useful for sport fishing. To this end, road allowances should be kept open, grazing and timber lease operators should not be allowed to close leased lands to access by anglers and development plans for the East Slopes should include provisions for optimal access routes.

G7. FISH PLANTING

While the stocking of fish for recreational use is a recognized and much used method of maintaining fish populations, certain factors should be considered:

1. Sport fisheries generally are best managed on a sustained yield basis without artificial propagation. Enlightened fisheries management programs could produce quality sports fishing without endangering local stocks through fish introductions.
2. Exotic species should be stocked only if no native species can be used.
3. The introduction of fish diseases via planting programs is a real possibility. The effects of such disease can extend across park, provincial, and even national boundaries. The valuable headwaters in the East Slopes can be kept disease-free by proper management of native stocks, thus reducing the requirement for fish introduction into headwaters.

H. WILDLIFE IN THE EAST SLOPES

The East Slopes contain several physiographic and vegetative zones which provide the diversity of habitats necessary to maintain the present rich and diverse wildlife of the region. Over a period of many geological eras intricate ecological relationships have evolved, producting a type of dynamic stability among the biotic communities which permits both a maximum diversity and a symbiotic balance within the plant and animal communities. Each wildlife species occupies its own niche and contributes toward the dynamic balance found at the various biological levels. The most conspicuous and economically important wildlife are the big game animals such as elk, moose, deer, bighorn sheep and bears. Many other resident mammal species occur. They are not only necessary to the web of life but also provide considerable sport and aesthetic enjoyment to humans. The birds of the East Slopes, although somewhat less spectacular than the big game, are every bit as interesting and valuable. Over 200 species of birds inhabit this area, ranging in size from the 3½-inch-long rufous hummingbird to the golden eagle with a 6-to 7-foot wing span. They play a major role in helping to maintain a check on the insect component of East Slopes ecosystems which, without control, could cause serious undesirable effects to forests as well as human annoyance.

There are many instances where migratory wildlife populations cross a common boundary between the East Slopes region and

Waterton Lakes, Banff and Jasper National Parks. Thousands of native ungulares traditionally spend the summer inside the National Parks and winter in the East Slopes. The welfare of such wildlife is threatened when man's activities disrupt habitat or wildlife behavior on critical winter ranges or along seasonal migration routes. Many actions, such as the creation of a provincial wilderness area adjacent to a National Park, require cooperative planning between Federal and Provincial authorities so as to satisfy the management objectives of both groups where migratory big game populations are concerned. If, for example, a particular area in a National Park is overpopulated it would be most beneficial to harvest some of this population while it is on provincial lands rather than protect it with a wilderness area closed to hunting.

Two wildlife species, the osprey and northern rocky mountain cougar, which are in danger of extinction in Canada, depend heavily upon habitat within the East Slopes. Future developments within the East Slopes will have a major effect on the survival of these animals. The existence of certain wildlife species, such as bears, is now threatened in areas of increasing human usage. As human activity in remote areas increases, confrontation between man and wildlife also increases. Transient carnivore species such as bears, wolverines, and wolves are vital elements of National Park ecosystems in Western Canada and yet are generally considered nuisance species requiring drastic control measures on provincial East Slopes ranges.

The National Parks will be unable to maintain these important components of our natural heritage unless reasonable protection is afforded them when their ramblings take them onto ranges outside the parks.

H1. MIGRATORY BIRDS

Bird populations are widely dispersed and less conspicuous than those of most mammals and as a result man's activities tend to be more subtle in their impact. There are no large populations of birds in the East Slopes which are a major economic resource such as waterfowl are on the prairies. Bird life such as bluebirds, waxwings, blue grouse, Canada jays, eagles and woodpeckers, to name but a few, is aesthetically important. Forests, meadows and subalpine communities provide pleasing landscapes, and can become vividly alive with the songs, intriguing flights, and everyday behaviour of bird life.

<u>Many species of migratory birds are influenced by the river systems both within and beyond the East Slopes</u>. These include the continental waterfowl populations, and numerous song and insectivorous bird species. Almost all the major rivers leaving the East Slopes contribute to the production of the Canada goose. Although exact population figures are lacking, these rivers support over 10,000 Canada geese in Alberta (pers. comm. E. Ewaschuk, Ducks Unlimited) and therefore make a very significant contribution to the local goose

population. The mountain watersheds also contribute to waterfowl production and migration on the prairie rivers and northern deltas. In this respect, major changes to these river systems could affect millions of waterfowl. Developments such as dams change seasonal flow patterns of a river which in turn alters the ecology of the river islands and deltas. By eliminating periodic flooding of these areas vegetative succession is allowed to advance toward climax. This results in shrubs, sedges and grasses being replaced by mature trees which provide less cover and feeding habitat for geese and many other wildlife species. The deleterious sequence of events which took place at the Peace-Athabasca Delta following the building of the Bennett Dam in British Columbia is a good example of the serious effects of dams on wildlife.

There are many unexplored relationships between migratory birds and their environment in the East Slopes. For example no one has satisfactorily investigated how certain forestry practices affect bird distributions. More must be known about these associations before potential environmental impacts of resource development can be adequately assessed.

It is recognized that the greatest number and variety of bird species exist where shrub and deciduous stages of forest development are found in association with the more mature coniferous vegetation. A diversity in habitat will usually result in a diversity of wildlife species and a more stable ecosystem.

Biocides can have an unbalancing effect on existing natural ecosystems. A study in New Brunswick[1] showed that a significant decline in the local bird population followed the application of insecticides to large areas of forest. Considering the possible impact of insecticides and other chemical sprays on forest bird populations, serious consideration should be given to the value of the bird resource and possible deleterious effects before such practices are sanctioned in the East Slopes forests.

H2. UNGULATES

The primary wild ungulates of the East Slopes are elk (*Cervis canadensis*), moose (*Alces alces*), white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), bighorn sheep (*Ovis canadensis*), woodland caribou (*Rangifer tarandus*), and mountain goat (*Oreamnos americanus*),

These species are generally associated with three broad plant communities; grasslands, mixed transition forest, and wet bottomlands.[2] Grasslands receive extensive use both in the upper

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[1] Fowle, C.D. 1972. Effects of phosphamidon on forest birds in New Brunswick. Canadian Wildlife Service Report Series - No. 16. 25 pp.

[2] Stelfox, J.G. and R.D. Taber. 1969. Big game in the Northern Rocky Mountain Forest. Reprint from: Coniferous Forests of the Northern Rocky Mountains, Proceeding of 1968 Symposium, Centre for Natural Resources. University of Montana Foundation. pp. 197-222.

alpine areas and the transition and prairie grassland areas during various periods of the year. The mixed transition forest is composed of either conifers or a mixture of coniferous and deciduous trees, usually with a rich herbaceous understory. This zone is the year-round habitat for white-tailed and mule deer, elk, and often winter habitat for mountain sheep. The upper transition or sub-alpine zone between the coniferous forest and the alpine grasslands is summer range for elk, moose and mule deer, and winter range for mountain sheep and goats.

The wet bottomlands are generally covered by willow, dwarf birch, sedges and grasses which support moose year-long and mule deer and elk in the winter.

Forage preferences indicate that ungulates generally feed on open grass and shrub areas or under open canopy coniferous forests where sunlight is intense enough to produce an understory of forage. Closed canopy coniferous forests are of little value for forage but are used for shelter and travel areas when snow depth in open areas impedes movement.[3] It is reasonable to assume that almost all areas of the East Slopes harbour one species of ungulate or another. Some of these habitat types are less abundant than others. The sub-alpine grasslands, for example, are available in only a very limited supply compared to the mixed transition forest and the wet bottomlands. Therefore ungulate species using this grassland are relatively limited

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[3]Stelfox, J., E. Telfer and G. Lynch. 1972. Effects of logging on wildlife in the Alberta foothills. Unpub. mimeo. 9 p.

and those using mixes forest and bottomlands are relatively plentiful.

Most ungulate populations are migratory to a certain degree, making it necessary that ranges used during each season be maintained in adequate condition. Once it was thought that only winter range was critical. However, summer ranges are often critical as well because a reduction or elimination of summer range will increase demands on the winter range, to the detriment of the ungulates. Winter ranges in the East Slopes are extremely important as they usually comprise 10 per cent or less of the total land area. During severe, deep-snow winters the area available to ungulates may be even less than this amount. Winter range for mountain sheep, elk and goats is often located on south and west facing slopes and alpine bench lands where winter sun and winds minimize snow depths. Mountain sheep and goats also must have escape terrain - generally in the form of steep rocky cliffs - in close proximity to their feeding area, thus further reducing the usable winter range.

Alluvial flats and valley bottoms are important winter ranges which generally receive heavy winter use by moose, elk and deer. In these areas large amounts of willow, poplar and birch browse usually occur in close proximity to dense stands of conifers which are utilized for shelter and escape cover.

H3. CONFLICTS AND COMPATIBILITY WITH OTHER USES

The successful production and maintenance of wildlife populations, particularly ungulates, along the East Slopes, will

require the recognition and resolution of various conflicts with other land uses including timber production, mining, livestock grazing and tourism.

Game and timber can be produced together to the benefit of the public. Indeed, logging could vastly improve the carrying capacity of much of the winter range on the East Slopes, particularly where large tracts of old-growth coniferous forests are being removed, but care must be taken to leave an interspersion of patches of heavy timber large enough to provide adequate winter shelter and escape cover. Large-scale continuous clearcuts could have particularly adverse effects on large ungulates.

Ungulate populations should also be adequately harvested to allow optimum forest regeneration within recent cuts. Once a potential winter range has been opened by fire or logging, heavy browsing pressure of game wintering there may delay, retard or even eliminate regeneration of coniferous forests unless the animals are adequately harvested.[4,5]

There are other situations which provide the opportunity for conflicts between wild ungulates and other resource uses. Among these are activities of extractive industries such as mining or oil and gas production. The exploration phases of these operations can cause as many problems as the production phase. Initial exploration

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[4] Stelfox et al. op. cit page 82.

[5] Niels, George, Lowell Adams and Robert Blair. 1955. Management of white-tailed deer on ponderosa pine. Trans. 20th N.A. Wildlife Conf. p. 539-550.

activities, particularly seismic line clearing, can benefit wildlife up to a point by providing belts of forage within mature forests that have a maximum of cover and a minimum of forage. However, duplication of lines and development of access routes can adversely affect wildlife habitat and populations by reducing the amount and dispersion of cover below an acceptable level, damaging unstable soils, and by affording so much human access that harassment becomes a limiting factor to ungulate populations.

Livestock grazing in the foothills and subalpine areas is presently a source of conflict. <u>Livestock and big game do not necessarily have to be using the same areas at the same time to cause interaction</u>. If livestock use big game winter ranges during the summer to the extent that insufficient forage remains to support the big game animals throughout the winter then significant big game losses can be expected. <u>The old belief that livestock grazing of East Slope meadows will not interfere with big game needs because the big game have all the rest of the area to live in is a fallacy</u>. These small meadow areas are the prime wintering ranges of the native grazing ungulates and are vital to their survival. Many East Slope areas are subject to grazing, largely by cattle, and the impact on wildlife is poorly documented. Provincial grazing authorities are trying to understand this problem and to adjust livestock grazing to minimize conflict with big game animals. However, the problem is serious and poorly understood at present. Until further studies

provide the necessary answers to alleviate the conflict, grazing allotments should be restricted in areas known to be used heavily by game.

It is obvious that ungulates, though fairly wide-ranging in nature, are not distributed randomly throughout the East Slopes and that there are certain areas which must be considered critical. Any activity, be it the extraction of renewable or non-renewable resources, or the promotion of non-consumptive wildlife-based industries, should be based on sound ecological inventories and carefully managed with stringent regulations where it falls within an important ungulate range.

H4. SOME ECONOMIC CONSIDERATIONS

A 1965 study of game animal populations within a 12,235 square mile area near Edson, showed that out of an estimated population of 36,719 animals (including 2,500 grizzly, black bear and cougar), the potential annual harvest was 8,690 animals. The potential revenue from this harvest was $3,572,280 or about $300.00 per square mile. Actual harvest at that time provided a government and business revenue of $125.00 per square mile.

Rocky Mountain sheep populations in the sub-alpine areas on the East Slopes have been estimated at a high of 4,500 animals. These are roughly distributed as follows. Lethbridge region 10 per cent, Calgary region 17 percent, Red Deer region 35 per cent, Edson region 40 per cent (pers. comm. Alberta Fish and Wildlife Division).

The cost to non-residents who have legally hunted Rocky Mountain bighorn sheep during the last year has reached and exceeded \$2,000 per hunter with a success ratio of less than 50 per cent. The value to the provincial economy of each trophy sheep removed from the province is now between \$4,000 and \$5,000 (pers. comm. J. Stelfox) and the worth of these animals should increase greatly in the future.

I. OUTDOOR RECREATION IN THE EAST SLOPES

Outdoor recreation is a "catch-all" phrase which may be applied to any outdoor leisure-time activity engaged in by man. It may be intensive in the use of land and facilities, as is trailer camping, or extensive, as is wilderness hiking. Although specific kinds of recreation require particular physical and biological features, such as mountains for climbers or trout streams for fly fishermen, many are dependent upon a complex of resources which embrace the entire environment, as is the case of wilderness hiking.

The diversity of land and resources in the East Slopes of Alberta provides opportunities for a broad spectrum of recreational activities. These activities are developed to varying degrees at present and all can be expected to increase as the population grows and as disposable income and leisure-time increase and transportation technology improves. For example, the populations of Calgary and Edmonton are known to have increased 22 and 16 percent respectively from 1966 to 1971[1] and the income, leisure-time and outdoor recreation needs associated with urban living increased accordingly.

The provincial government provides approximately 85 percent of all outdoor recreation facilities in the East Slopes, in the form of Provincial Parks, recreational areas, historic sites, natural areas, wilderness areas, roadside campsites and view-points.

Figure I-1 shows the distribution of provincial parks and campsites within the East Slopes area, with major access routes.

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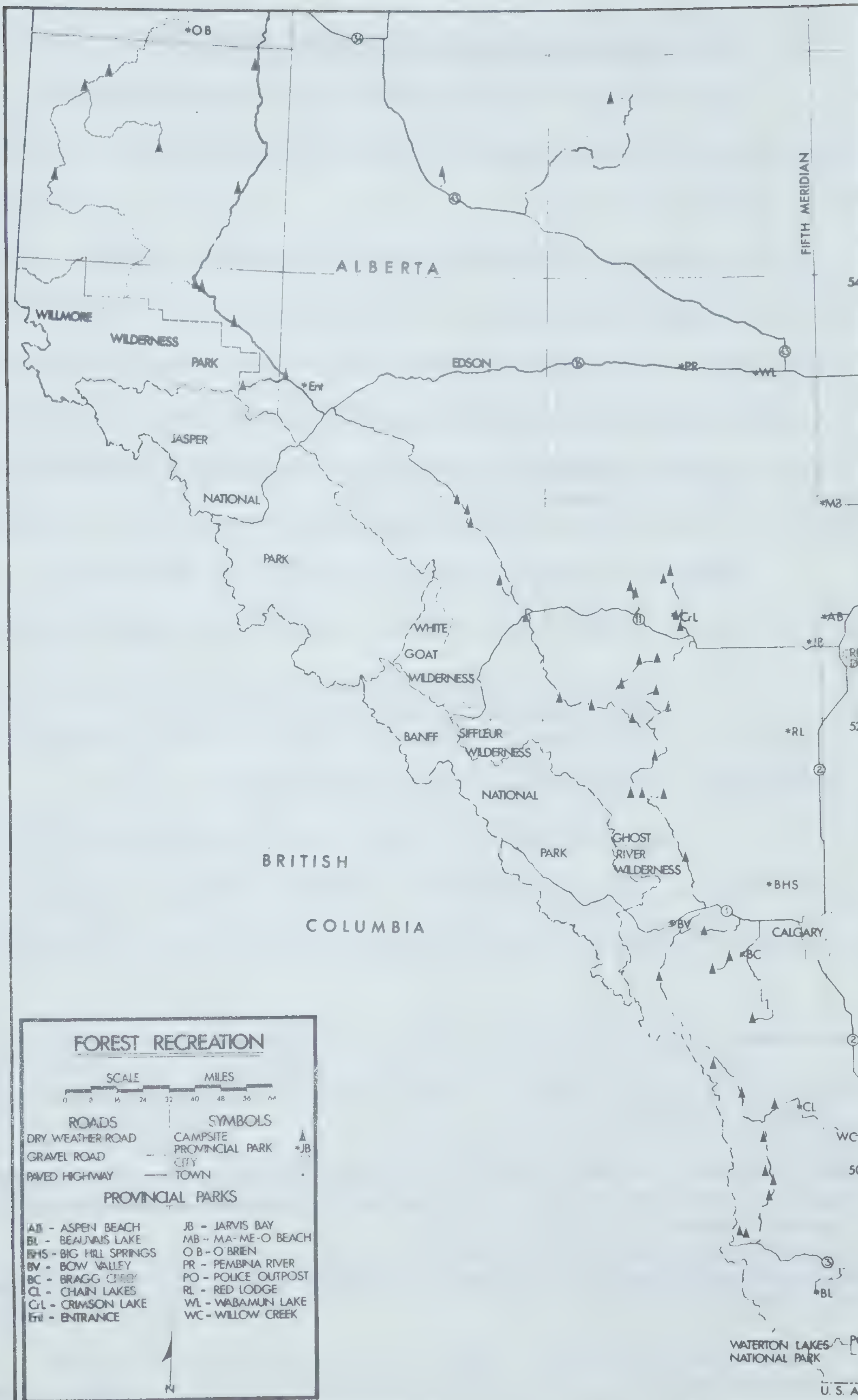
[1] Statistics Canada. 1971. Census of Canada. Vol. I. Part I. Cat. No. 92-708.

Figure I-1


ALBERTA
BRITISH
COLUMBIA
FIFTH MERIDIAN
WILLMORE
WILDERNESS
PARK
JASPER
NATIONAL
PARK
EDSON
WHITE
GOAT
WILDERNESS
BANFF
SIFFLEUR
WILDERNESS
NATIONAL
PARK
GHOST
RIVER
WILDERNESS
CALGARY
WATERTON LAKES
NATIONAL PARK
U. S. A.
FOREST RECREATION
SCALE MILES
ROADS
DRY WEATHER ROAD
GRAVEL ROAD
PAVED HIGHWAY
SYMBOLS
CAMPSITE
PROVINCIAL PARK
CITY
TOWN
PROVINCIAL PARKS
AB - ASPEN BEACH
BL - BEAUVAIS LAKE
BHS - BIG HILL SPRINGS
BV - BOW VALLEY
BC - BRAGG CREEK
CL - CHAIN LAKES
CrL - CRIMSON LAKE
Ent - ENTRANCE
JB - JARVIS BAY
MB - MA-ME-O BEACH
O B - O'BRIEN
PR - PEMBINA RIVER
PO - POLICE OUTPOST
RL - RED LODGE
WL - WABAMUN LAKE
WC - WILLOW CREEK
N

II. SUPPLY, DEMAND AND RECREATION PLANNING

The details of supply, demand and planning for outdoor recreation in the East Slopes are primarily the responsibility of the provincial government.

Statistics relevant to outdoor recreation demand in the province as a whole were published recently[2]. An information and planning study for outdoor recreation in Canada, initiated as a joint Federal-Provincial project in 1967, as the Canadian Outdoor Recreation Study (CORDS)[3], has produced some demand information for Alberta, but not specifically for the East Slopes.

Within the East Slopes area in 1970-71[4] nearly 50 per cent of visits to sites other than Provincial Parks were family outings with picnics and scenery enjoyment as major objectives. Approximately 25 per cent of visits were fishing trips and 25 percent hunting trips. Approximately ½ million visits were made in total.

Provincial Parks in the East Slopes accommodated 1½ to 2 million people on a day-use basis in 1970-71[4]. Table I-1 shows a measure of change in use for selected Provincial Parks from 1965

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[2]Anon. 1972. Travel, tourism and recreation - a statistical digest. Statistics Canada.

[3]Anon. 1968. The administration of outdoor recreation in Canada. Canada. Canadian Council of Resource Ministers. 1170 Beaver Hall Square, Montreal 111, P.Q. Vol. II.

[4]Figure from Alberta Department of Lands and Forests. Annual Report for 1970-71

to 1970, and illustrates the rapid rate of increase in use.

An inventory of supply, in terms of the capability of land for outdoor recreation, is available for the East Slopes[5] in the Canada Land Inventory.

Planning methodology for outdoor recreation is now quite well developed, both through CORDS[6] and through the Tourist and Outdoor Recreation Planning Study (TORPS) in Ontario[7]. Both of these could provide planning guidelines for the East Slopes in the areas of demand derivation, investment and management planning, and evaluation of alternative policy decisions.

There were 8 government departments and 13 government agencies concerned with outdoor recreation in Alberta in 1968[8].

I2. CONFLICTS AND COMPATIBILITY WITH OTHER USES

The degree of conflict and compatibility which now exists or may develop in the future between recreation and other uses of land in the East Slopes depends on a variety of factors, including the nature and intensity of each use and the extent to which they

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[5]Anon. 1969. The Canada Land Inventory - land capability classification for outdoor recreation. Department of Regional Economic Expansion, Report No. 6. Queen's Printer, Ottawa. 114 pp. and maps.

[6]Communication with the Outdoor Recreation Research Section, Planning Division, National and Historic Parks Branch, Dept. of Indian Affairs and Northern Development.

[7]Anon. 1972. Tourist and outdoor recreation planning study Progress Report No. 2. The Ontario Dept. of Tourism and Information, Parliament Buildings, Toronto, Ontario.

[8]Anon. 1968. The administration of outdoor recreation in Canada. Canada. Canadian Council of Resource Ministers. 1170 Beaver Hall Square, Montreal 111, P.Q. Vol. II.

TABLE I-1. Total vehicle count for selected provincial parks within the East Slopes 1970-71.[1]

Provincial Park	Numbers of Motor Vehicles 1965	1970	5-Year Increase %
Aspen Beach	85,066	166,194	95.3
Beauvais Lake	6,456	18,382	184.7
Big Hill Springs	7,275	13,928	91.4
Bow Valley	22,708	57,382	152.6
Bragg Creek	1,672	18,426	1002.0
Chain Lakes	-	32,947	-
Crimson Lake	5,006	40,179	702.6
Entrance	1,967	9,777	397.0
Ma-Me-O Beach	4,942	12,440	151.7
O'Brien	8,085	10,852	34.2
Pembina River	10,756	17,514	62.8
Wabamun Lake	46,613	99,993	114.5
Willow Creek	4,424	12,011	171.5
		Mean	263.3

[1] Source: Alberta Department of Land and Forests, Annual Report for 1970-71.

overlap in time and location. Use may be mutually exclusive, such as the use of land for a natural area, an archaeological reserve or a wilderness trail and surface coal mining. They may be competitive as is the case with livestock grazing and elk on the same range, or complimentary as is often the case with road access development for industry, and hunting and camping.

In the East Slopes, activities which may alter or destroy soil, fauna, vegetation or watercourses, or change the appearance of the landscape, have the greatest potential for conflict with recreation. This includes livestock grazing, commercial timber harvesting, and the exploration, and extraction and processing phases of the coal, oil and gas industries.

The prevention and resolution of conflicts is a major function of land use planning. Guidelines to prevent or reduce conflicts should reflect biological principles such as those outlined previously for water, fisheries and wildlife. Where development regulations exist they must be enforced by adequate staff and budgets to be effective.

Concern for aesthetics in the mountain landscape should receive special attention as the kind and degree of landscape disturbance by industrial development increases. A particular example in the sub-alpine and alpine areas of the East Slopes is the exploration for surface coal deposits using bulldozers. Examples of mountain terrain of particular aesthetic value, which has been

scarred by extensive coal exploration can be seen on the Oldman River, Savannah Creek, Panther River, Skeleton Creek, Cardinal River, and the Smoky River. Unless new exploration techniques are developed and close regulation on existing exploration techniques is achieved a large proportion of the landscape of the East Slopes will soon be permanently scarred. Road access development, forest harvesting methods and equipment and oil and gas exploration methods should be examined with a view to creating less disturbance in the East Slope landscape. Industrial activities of all kinds should be planned and monitored to minimize the destruction of the high quality air and water in the East Slopes which are vital parts of the recreation complex.

I3. SOME ECONOMIC CONSIDERATIONS

Tourism is a major industry in Alberta and outdoor recreation is a major tourist activity. Expenditures by Canadian tourists in Alberta in 1971 totalled $241,435,000.[9] The proportion of this business which was directly related to outdoor recreation in the East Slopes is unknown, but was probably substantial.

The economic evaluation of outdoor recreation in the East Slopes will become increasingly important in the future as alternative land uses are compared for planning and development purposes.

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[9]Anon. 1971. Canada Travel Survey, 1971. Highlights. Dep. Ind. Trade Com., Travel Ind. Br., Ottawa. Res. Bull. No. 1. 140 pp. (Edmonton Journal, Dec. 27, 1972, Page 32, reported all tourist expenditures in 1972 as $335,000,000).

Two distinct approaches to placing a value on outdoor recreation opportunities are commonly found in the literature[10]. The monetary approach attempts to place a direct dollar or proxy dollar estimate on recreation experience, while the non-monetary approach attempts to evaluate the attractiveness of an area either by the reaction of people to photographs or by personal interviews at recreation sites.

3a) MONETARY APPROACH

The most common way to obtain a monetary estimate is to construct a demand curve (Figure I-2) whose vertical axis measures travel costs, including entrance fees, which reflect the distance travelled, and whose horizontal axis measures the number of participants per 1,000 population. The resulting curve can be used to determine the effect of changing fees or costs and can show the fee increase which will generate the largest revenue. The greatest weakness of this approach is that only cash costs to the consumer are measured and there is a theoretical question concerning the validity of projecting demand on travel costs only.

Another technique, not unique to outdoor recreation, employs the concept of opportunity cost. Briefly this entails imputing a value for outdoor recreation by assessing the value of the best alternative (opportunity) use of the same land and capital. For

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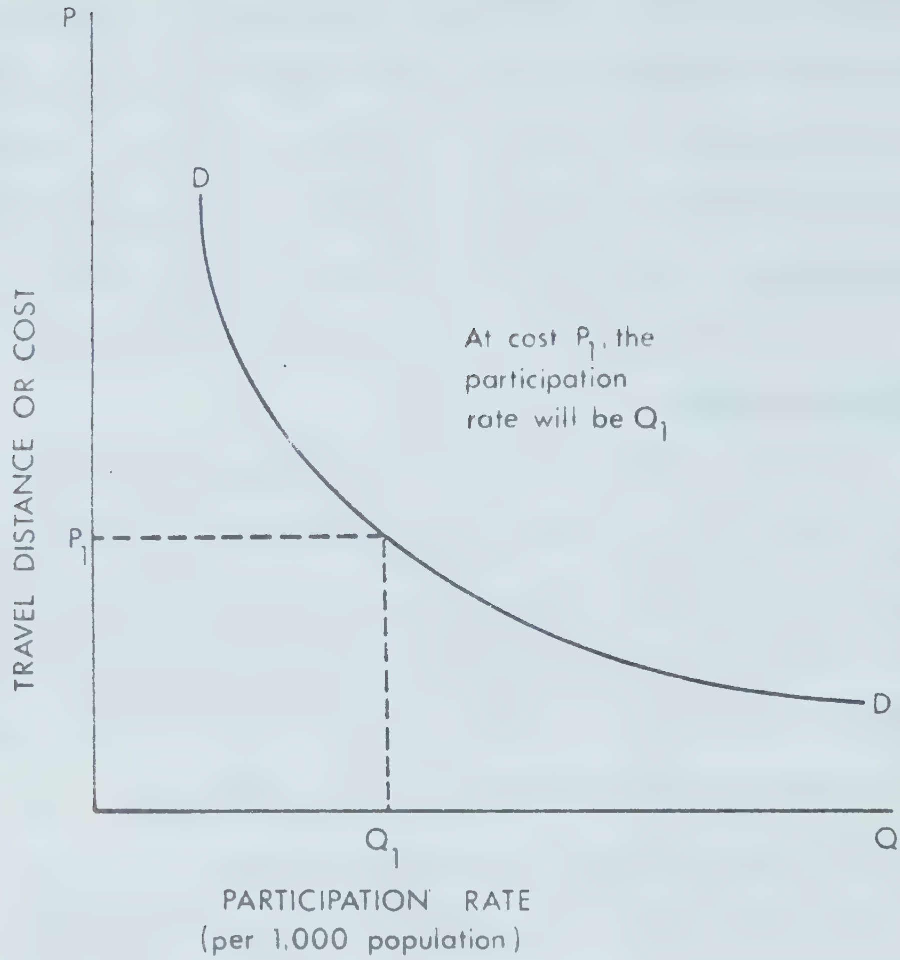
[10] Coomber, N.H. and A.K. Biswas, 1972. Evaluation of environmental intangibles. Review of techniques. Ecological Systems Branch Research Co-ordination Directorate, Policy, Planning and Research Service, Environment Canada, Ottawa. 74 pp.

Figure I-2



TYPICAL MARSHALLIAN DEMAND CURVE
WITH PROXIES FOR P AND Q

example, the best alternative use of the Kananaskis River Valley may be the strip-mining of the coal resources. Assuming that coal mining and recreation are mutually exclusive, the net returns that are foregone from coal mining represent the opportunity cost for the present recreational use of the Kananaskis Valley. However, this value does not reveal the Kananaskis Valley's "true" scenic value. It only shows what would be foregone in order to enjoy the scenic value of the area, and as such probably underestimates the value of recreation. The chief weakness of the opportunity cost approach is its tendency to measure the minimum value of a use.

The value of the recreation equipment or the effect on Gross National Product from equipment sales and recreation developments is another simple approach to recreation evaluation where such data can be disaggregated for the specific area. This approach does not distinguish between the value of recreation opportunities per se and the value of the other services related to recreation facilities. Therefore it will likely overestimate the value of recreation.

3b) NON-MONETARY APPROACH

The non-monetary techniques revolve around subjective ranking schemes based upon either viewing photographs which depict the appropriate scenery and registering a preference (aesthetic approach), or taking on-site participation rates (visitor days) and

correlating the results with a measure of distance travelled (attractiveness approach).

In the aesthetic approach, the response is commonly correlated with quantitative factors which can be measured on the photo such as acres of water or distance to water. Because photos are employed, both users and non-users can influence the results. However, the results only measure preference for a photograph, not the actual landscape.

The attractiveness approach avoids the problem associated with photographs by utilizing the actual site, but this does not account for the preferences of non-users, who make up part of the demand.

Both the asethetic and attractiveness methods measure subjective preferences which cannot be expressed in the same common denominator ($) as coal, oil, gas, forage and timber, all of which may be competing for the same acreage. Since many of these uses are conflicting, a common values measure would aid the decision maker in his choice of preferred use. It is important to consider the meaning of "value" and "value to whom". This is a crucial point which all of the above methods, except opportunity cost, ignore.

Value can only be defined in terms of a particular reference group, and value for the same object changes as the reference group changes. The value of outdoor recreation varies between the recreation equipment industry, motel owners, Canadians, Albertans, Calgarians, the affluent and the poor. Therefore the value of

recreation must be determined with reference to a specific group. For purposes of the following discussion, the reference group is assumed to be residents of Alberta.

I4. SUGGESTED IMPLICATIONS ARISING FROM DEVELOPMENT OF RECREATION OPPORTUNITIES IN THE EAST SLOPES

To develop recreation opportunities on the East Slopes the public must forego both a land use opportunity cost and development costs. Specific revenue flows are foregone when land is reserved exclusively for recreation use or where other uses are excluded because of incompatibility. In the latter case the opportunity cost is the value of the incompatible use foregone. Therefore, the first step is to determine the opportunity cost.

Such a cost only reflects the revenues foregone if the land is placed in some form of holding category for extensive recreation use.[11] If the land set aside were subsequently developed for more intensive recreation uses such as camping, then additional costs would be incurred in the hope of generating benefits of a greater magnitude than the costs. Therefore the net benefits from development must be weighed against the value of the best alternative use of the site.

If the monetary returns from a recreation development are negative, which is most often the case, and when the best alternative use (opportunity) has a positive return, then the non-monetary (intangible) benefits from recreation are assumed to be worth at

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[11]Extensive refers to a use which can take place with no capital improvement or operating expenditures outside normal protection costs. Wilderness and most hunting and fishing qualify as extensive recreation uses.

least as much as the opportunity cost plus the monetary loss (costs minus returns) from the recreation development.

In order to assess recreation value or worth it is necessary for the public to know the opportunity cost, the costs and returns from development, and the beneficiaries of development.

Such information will demonstrate to taxpayers the contribution they make in supplying outdoor recreation opportunities, the revenues generated, the resulting subsidies, if any, and the benefitting consumer group. This information does not provide the social and monetary value of the recreation which is only determined by assessing the question, are the benefits received by consumer group "A" along with the net revenues generated really worth the cost, i.e., is there a fair return from the use of public resources?

With reference to the last point, <u>recent evidence suggests that the net effect of the cost and revenue flows for camping results in a substantial subsidy to middle and high income families</u>[12] Table I-2 illustrates the sizeable magnitude of such subsidies per family day for camping. The beneficiaries of these subsidiaries are middle and high income families who already own camping equipment. These figures, while specific to the Lake States, do indicate that the net revenue flow to taxpayers is negative and of a large magnitude. These direct costs coupled with the opportunity cost foregone most certainly provide the appropriate base for decisions concerning resource allocation.

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[12] Manthy, R.S. and T.L. Tucker, 1972. (See Table 1 for full citation).

TABLE I-2

AVERAGE COST PER FAMILY VISITOR DAY TO PUBLIC AGENCIES AND FEES CHARGED FOR CAMPING (1968)[1]

Cost	Camping	
	Modern[2]	Primitive[3]
Agency Cost[4]	$ 9.23	$ 4.10
User Fee	$ 2.90	$ .47
Subsidy[5]	$ 6.33	$ 3.63

[1] Data reflects the situation in the Lake States and specifically Michigan.

[2] Fully serviced campgrounds with electrical and sewage hookups.

[3] Pit toilets and non serviced.

[4] Operating, maintenance, and capital improvements incurred by managing agency.

[5] Average direct daily cost not covered by fees paid.

Source: Manthy, R.S. and T.L. Tucker. 1972. Supply costs for public forest land recreation. Mich. State Univ., Agric. Exp. Stn., East Lansing, Mich. Res. Rep. 158.

Currently medium to high income foreign and Canadian campers are subsidized in Alberta. Does this result in an adequate return to all Albertans for the use of their resources? And of equal importance, does the return go to those for whom it is intended? Ideally, government subsidies for consumer goods should fall progressively to those unable to acquire a satisfactory quantity (determined socially and politically) in the market place.[13] Low income housing is an example. Apparently for camping the opposite is occurring.

Looking at the total revenue flow which is foregone because of recreation development the public is faced with the task of deciding whether the recreation benefits, monetary and social, are greater than, equal to, or less than the costs. If the cost exceeds the assessed benefits three options remain open. First, forego recreation in favor of the alternative uses. Second, leave land idle which may minimize the losses. Third, alter the revenue structure of recreation.

15. POLICY FORMULATION AND IMPLEMENTATION

The methodological framework for evaluation and analysis of resource use outlined previously can be employed in planning the development and use of natural resources in the East Slopes. However, once the direction and extent of resource use patterns that best serve the public interest are determined, public policies toward

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[13] Tucker, T.L. 1973. Outdoor recreation efficiently applied through pricing. Canadian Forestry Service, Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario, (In Press).

realizing this result are necessary. Existing economic incentives and resulting actions of private entities will not in themselves result in resource use consistent with maximizing social net benefits. The reason in part has to do with externalities and the existence of extra market values. In the absence of explicit policy to the contrary, emphasis tends to be placed on development of resources with direct market values at the expense of those with indirect or long-term social values.

Private resource users can be regulated through the imposition of penalties to discourage certain kinds of action and through provision of subsidies to encourage certain other kinds of action. Existing laws governing property may need change or new laws may be required to reduce conflict among resource users and to realign private benefits and costs with social benefits and costs. For example, while private land owners adjacent to public land may obstruct public access for hunting and fishing they are not compensated for wildlife use on their land (Appendix I). If they permit public access, they may suffer damage from trespassers. The solution may be public access and compensation to land owners.

Because of uncertainty, resource use plans[14] should include sufficient flexibility and safeguards to allow for changes as new developments take place or new information becomes available. Without flexibility in resource use, future outdoor recreation

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[14] Hopkins, F.S., (Jr.), G.H. Manning and H.H. Webster. 1973. Planning for the future of outdoor recreation: an economic viewpoint. Forest. Chron. 49(2):71-75.

needs may not be fulfilled in accordance with the best interests of the public because of irreversibilities created in the past.

J. FORESTRY IN THE EAST SLOPES

J1. THE LAND AND THE FOREST

1a) FOREST GEOGRAPHY

There are a total of 15 tree species represented in the East Slopes of Alberta, 12 of which are coniferous.[1] The most prominent species are white spruce, Engelmann spruce, alpine fir and lodgepole pine. Species association and distribution are more complex in the East Slopes than in other forested areas of Alberta because of extreme variations in relief, topography, local climate, geologic material and soils.

From the point of view of a land use planner, vegetation units such as Forest Regions and Forest Sections (Figure J-1)[2] may appear at first to represent units of direct ecological significance for planning. However, boundaries of Forest Regions, which are based on the presence of climax species (thought to represent stable, climatically controlled vegetation formations) and Forest Sections, which represent distinctive patterns of forest associations, may have very limited environmental significance.[3] They are intended as geographic descriptions only, but can serve, along with observed

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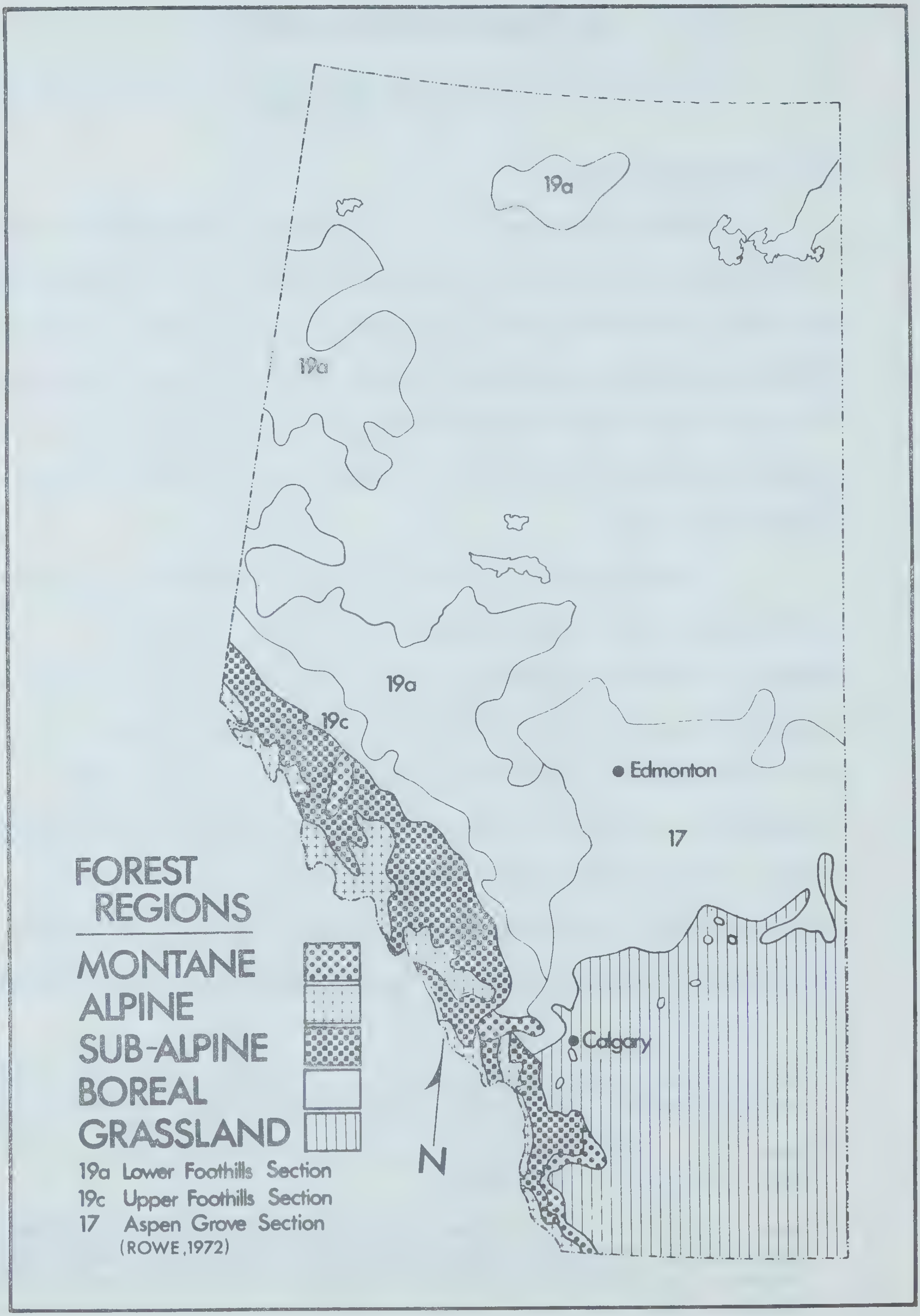
[1] For botanical names of tree species see: Hosie, R.C. 1969. Native trees of Canada. 7th Ed. Dep. Fish. Forest., Can. Forest Serv. 380 pp.

[2] Rowe, J.S., 1972. Forest Regions of Canada. Dept. Envir., Can. Forest. Serv., Pub. No. 13-0, 220 pp.

[3] Rowe, J.S., 1971. Forest Regions of Alberta. In: Proceedings of Symposium on Forest and Land Inventory for Management. Dep. Fish. Forest., Can. Forest. Serv., Northern Forest Research Centre, Edmonton, Alberta. pp 4-11.

Figure J-1


19a
19a
19a
19c
Edmonton
17
Calgary
N
FOREST REGIONS
MONTANE
ALPINE
SUB-ALPINE
BOREAL
GRASSLAND
19a Lower Foothills Section
19c Upper Foothills Section
17 Aspen Grove Section
(ROWE, 1972)

changes in soils, relief, topography and climatic factors, to establish ecologically significant boundaries, suitable for planning.

The reasons for inadequacy of vegetation units like Forest Regions or Sections as indicators of environmentally significant land units include:

1. Inability to define the taxonomy of forest trees, soils or climates with enough precision to provide a dependable, mappable association of different units.
2. Tree species which might be the best indicators of particular climates or soils, because of relative genetic uniformity and narrow ecological tolerance, may well be absent from an area, having been excluded by competing species of greater genetic diversity or by chance occurrences such as fire or disease.
3. Long-term changes in forest geography, related to the past 14,000 years of post-glacial history may still be in progress, confounding vegetation interpretation according to present observations.
4. Successional trends to "climax" forests are not necessarily directional, predictable or even uniformly observable from one area to another, from one time to another, or by different observers.

1b) PHYSIOGRAPHY

Physiography is a major determinant of biological productivity through influence upon local climate, soils, hydrology, flora and fauna

and has an important effect on how land can be managed. The physiographic features of the East Slopes could be mapped to form environmentally significant land use planning boundaries which would serve planners at all scales of detail, through a process of land unit refinement, as needed.[4]

In general, Forest Regions and Sections shown in Figure J-1 can be related to the five physiographic provinces discussed previously in this brief as follows:

Sub-Alpine		- Physiographic Provinces 1 and 2
Boreal	- Section 19C	- Physiographic Provinces 2 and 3
Boreal	- Section 19A	- Physiographic Provinces 3 and 4
Boreal	- Section 17	- Physiographic Province 4
Montane		- Physiographic Province 5

Although the physiographic provinces cited here are rather crude, and there is insufficient information available to describe them fully, they are presented as an example of a desirable method of stratifying the East Slopes for land use planning and management purposes.

J2. FOREST STATISTICS

For the purposes of this brief, statistics[5] were summarized for Alberta as a whole and for the "East Slopes" forest in particular. The latter is comprised of the Crowsnest, Bow, Clearwater-Rocky, Edson,

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[4] Lacate, D.S., 1969. Guidelines for bio-physical land classification for classification of forest lands and associated wildlands. Dep. Fish. Forest., Can. Forest. Serv., Pub. No. 1264. 61 pp.

[5] Most recent information available from the Forest Management Branch, Alberta Forest Service, Edmonton, with background from: Anon. 1961. Alberta forest inventory. Alberta Dep. Land. Forest. 40 pp.

Whitecourt and Grande Prairie Provincial Forests, which were chosen to provide examples of forest lands within the drainage basins designated for the hearings (see Figure J-2).

Forest land in Alberta is 95 percent publicly owned and in the East Slopes forest it is 90 percent publicly owned. Therefore the public has paramount responsibilities and opportunities to guide and control land use policy, planning and management of forest land.

2a) INVENTORY AND HARVEST

The first complete inventory of acreage and volume of forests in Alberta was completed in 1956 and is the basis for forest land planning and management today.

There are 96.1 million acres of forest land in Alberta, exclusive of patented land, of which 81.2 million acres are currently committed to timber production, within management units. The East Slopes forest contains 20.8 million acres in management units, 25.6 percent of the provincial total. This represents 38.9 percent of productive forest land,[6] 12.0 percent of potentially productive forest land, and 16.6 percent of non-productive forest land in the province.

There are an estimated 59.6 billion cubic feet of wood inventory on productive forest lands in Alberta, of which 54.2 billion cubic feet are currently committed to management, within timber management units. The East Slope forest contains 24.6 billion cubic feet in management units, 45.5 percent of the provincial total. This represents 53.0 percent of the

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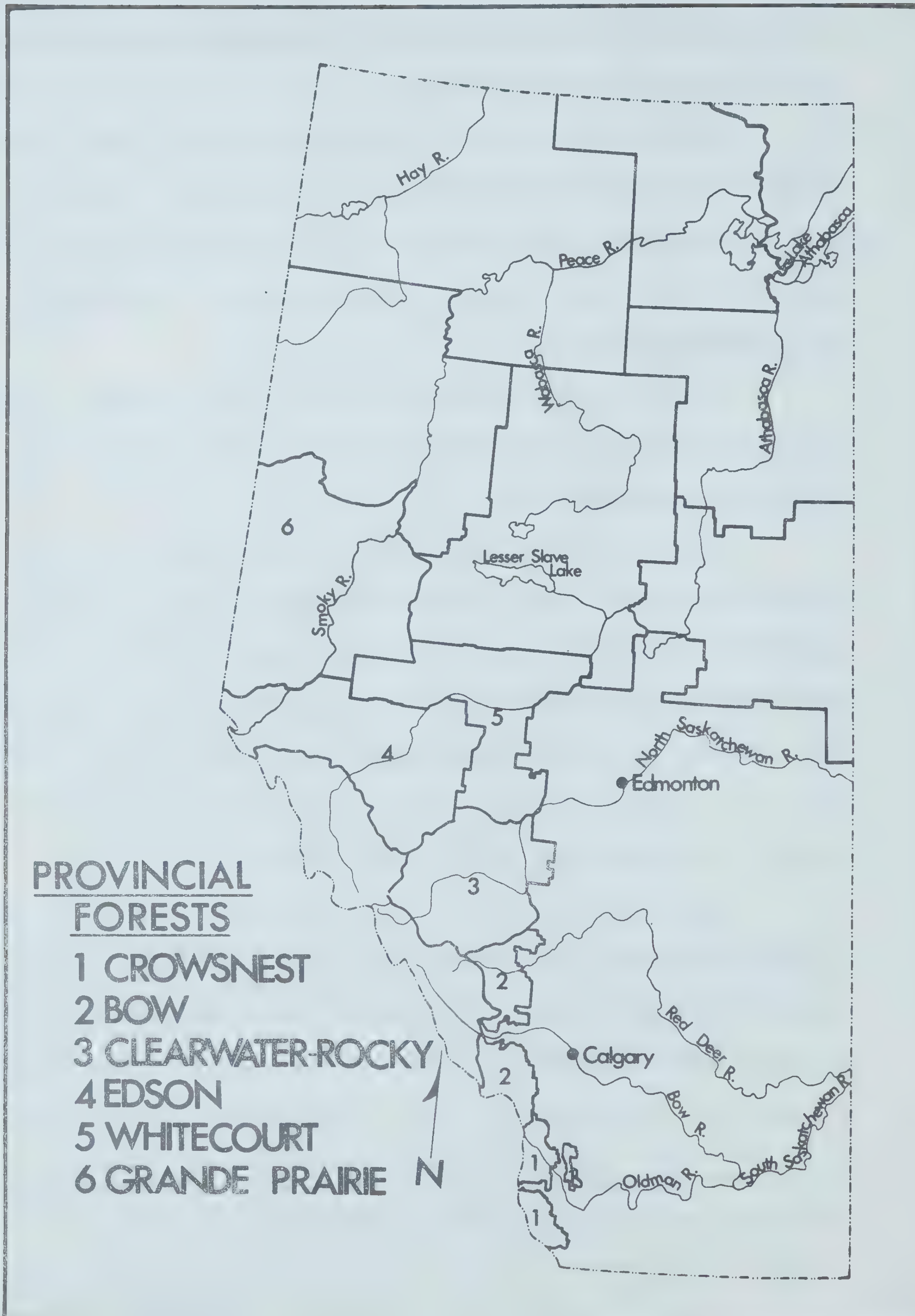
[6] Definition of technical terms in Appendix IV.

Figure J-2


Hay R.
Peace R.
Lake Athabasca
Wabasca R.
Athabasca R.
Lesser Slave Lake
Smoky R.
North Saskatchewan R.
Edmonton
Red Deer R.
Calgary
Bow R.
Oldman R.
South Saskatchewan R.
1
2
3
4
5
6
N
PROVINCIAL FORESTS
1 CROWSNEST
2 BOW
3 CLEARWATER-ROCKY
4 EDSON
5 WHITECOURT
6 GRANDE PRAIRIE

coniferous inventory, and 32.9 percent of the deciduous inventory in Alberta.

Figures J-3 and J-4 summarize forest acreage and volume information for the East Slopes. Both acreage and inventory volume increase from south to north, with 68.1 percent of productive forest acreage, 72.9 percent of coniferous volume and 84.6 percent of deciduous volume in the Edson, Whitecourt and Grande Prairie Forests. Deciduous volume is relatively insignificant south of the Edson Forest, with coniferous volume of primary significance throughout the East Slopes.

The East Slope forest is of major significance in terms of Alberta's forest inventory, as it contains 45.5 percent of provincial inventory volume on 38.9 percent of the province's productive forest lands. Coniferous forests are of particular significance, containing 53.0 percent of the total provincial volume on productive forest land within management units, with 72.9 percent of the coniferous forest of the East Slopes in the Edson, Whitecourt and Grande Prairie Forests.

The East Slopes is in need of re-inventory in the near future, because over 20 years has elapsed since the previous one, and significant changes in both forests and inventory requirements have occurred. There is a particular need to collect information on accessibility in the East Slopes forest inventory.

The 1973 allowable cut[7] for all Provincial Forests in Alberta is 511 million cubic feet and for the East Slopes forest it is 289 million

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[7] Applies to coniferous forests on productive forest land in management units only. The demand for deciduous forest products is insignificant at the present time.

Figure J-3

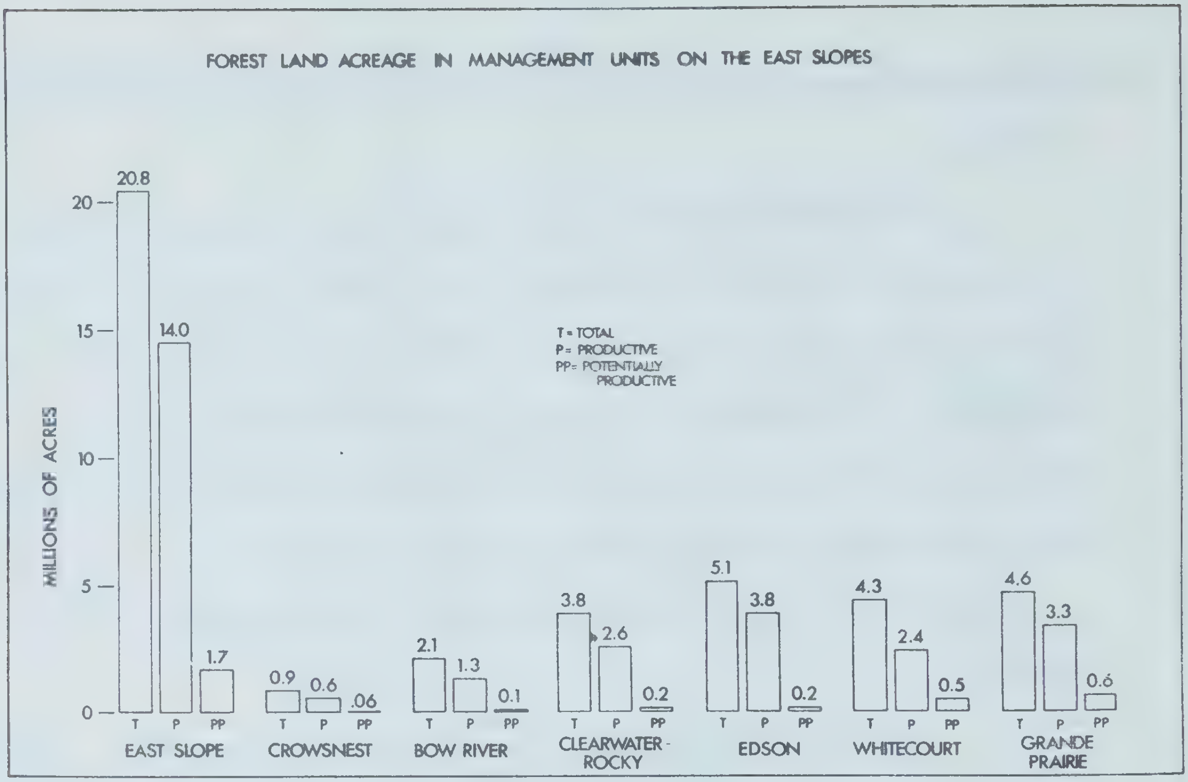
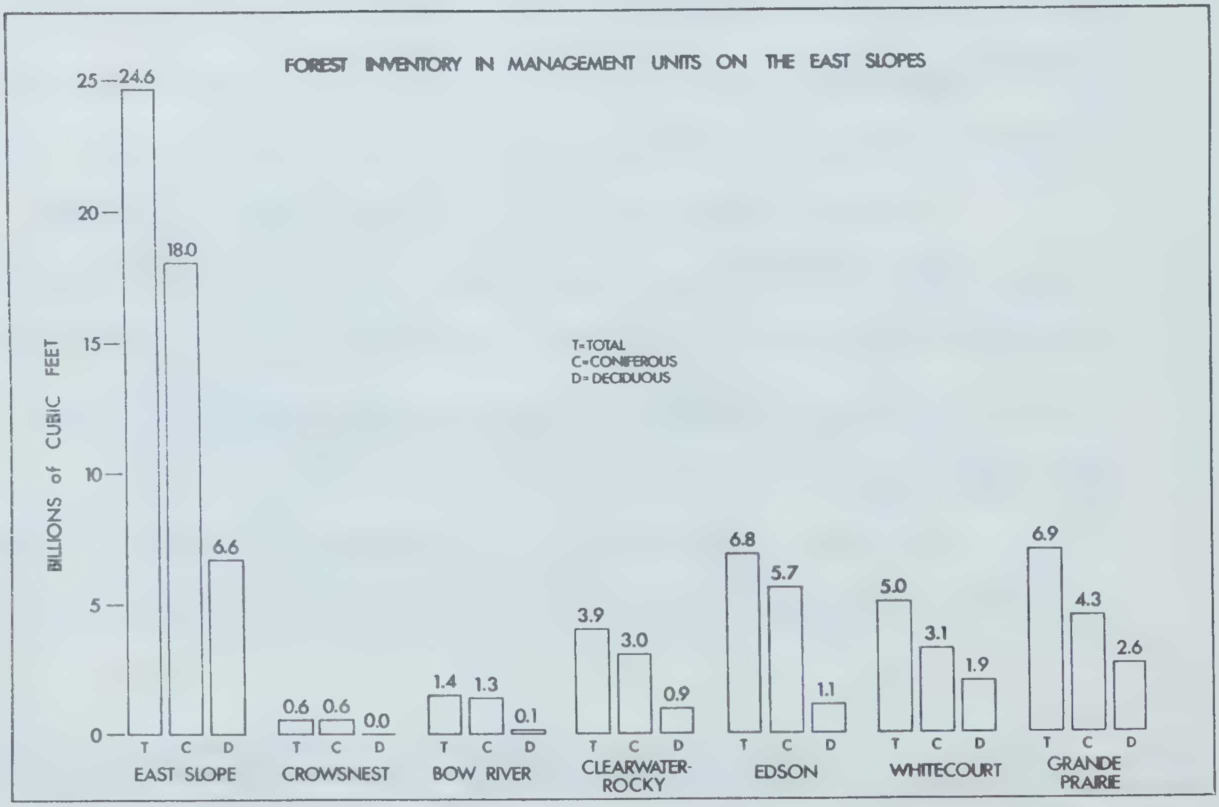


Figure J-4



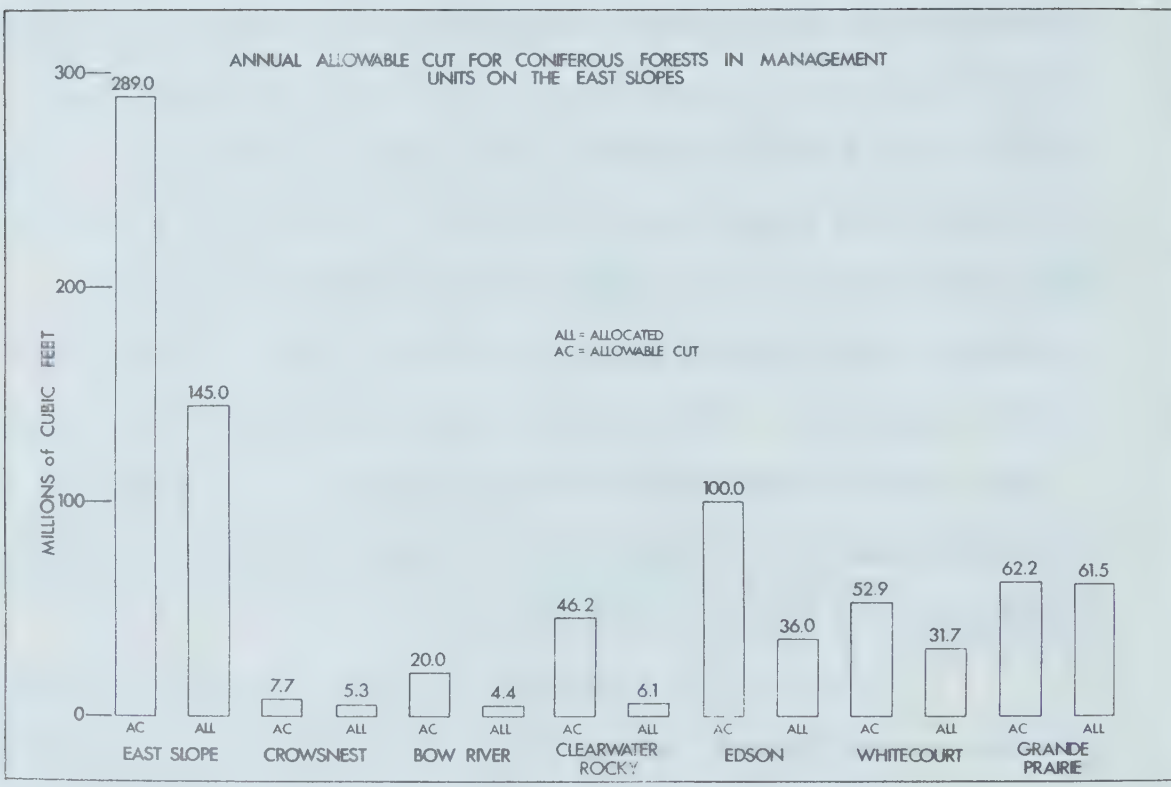
cubic feet, 56.5 percent of the provincial total. Only about 39 and 50 percent of the allowable cut in Alberta and the East Slopes respectively is actually allocated, with 72.4 percent of the total provincial cut allocated within the East Slopes.

Figure J-5 shows allowable cut and actual cut allocations for East Slope forests. There is a clear trend toward increased allowable cut and increased allocation of cut from south to north, with 75 percent of allocations to large pulp and sawmilling companies, under 20-year renewable Management Agreements, in the Edson, Whitecourt and Grande Prairie Forests. The remainder is allocated by timber license (quota), for periods up to 20 years, within distinct 5-year periods, and timber permit, which is basically an annual disposition. The Grande Prairie Forest is the only one with almost complete commitment of the allowable cut. At present 74.4 and 89.2 percent of allowable and allocated cut lies in the Edson Whitecourt and Grande Prairie Forests.

The net annual allowable cut for an area such as the East Slopes is periodically subject to revision. It is only as accurate as basic inventory figures, knowledge of growth rates, and estimates of depletion from previous cutting, fire insects and diseases, the last three of which are chance occurrences.

An important additional variable in the allowable cut calculations, particularly in mountainous areas like the East Slopes, is accessibility, both physical and economic. Recent studies in Sweden and Norway illustrate the importance of accessibility and terrain classification and methods of assessing it with respect to allowable cut and

Figure J-5


ANNUAL ALLOWABLE CUT FOR CONIFEROUS FORESTS IN MANAGEMENT UNITS ON THE EAST SLOPES
MILLIONS of CUBIC FEET
300
200
100
0
ALL = ALLOCATED
AC = ALLOWABLE CUT
289.0
145.0
7.7
5.3
20.0
4.4
46.2
6.1
100.0
36.0
52.9
31.7
62.2
61.5
AC
ALL
EAST SLOPE
CROWSNEST
BOW RIVER
CLEARWATER ROCKY
EDSON
WHITECOURT
GRANDE PRAIRIE

operating conditions.[8,9] Also, any changes in the timber growing base such as partial or total removal of land for recreation, mining or oil and gas field development affects inventory and allowable cut.

<u>In summary, 56.5 percent of the current allowable annual provincial cut, and 72.4 percent of the allocated provincial cut lies within the East Slopes forest, approximately 90 percent of the allocation being in the Edson, Whitecourt and Grande Prairie Forests. This clearly demonstrates the current importance of the three northern East Slopes Forests for commercial timber production in Alberta.</u>

The 6.6-billion-cubic-foot deciduous inventory in the East Slopes, most of it in the Whitecourt and Grande Prairie Forests, represents a major opportunity to increase the allowable cut.

2b) <u>GROWTH AND DEPLETION</u>

Information on growth rates of commercial timber species is important for inventory revision (and subsequent allowable cut calculation) and for purposes of financial analysis of investment opportunities in tree-growing, which is sensitive to time (growth rate) because of the compound interest effect.

The forests of the East Slopes have been organized under a long-term plan for management since 1956 and preliminary growth estimates have been assigned by management units, as shown in Table J-1 for each

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8 Von Segebaden, G. 1969. Studies on the accessibility of forest and forest land in Sweden. Royal Coll. Forests, Stockh., 64 pp.

9 Samset, I. 1973. Forest operations in a dynamic production forestry, illustrated by examples from Norway. Background Paper for 1973. H.R. MacMillan Lectures at Univ. of B.C. 41 pp.

TABLE J-1. ESTIMATED VOLUME GROWTH FOR EAST SLOPE FORESTS

Provincial Forest	Area (Thousands of acres) [1]	Current Growth Rates [2] 15 (Cu.Ft.)	25 (Cu.Ft.)	Potential Growth Rates [3] 20 (CuFt) (6.7)	40 (CuFt) (5)	60 (CuFt) (4)	80 (CuFt) (3)
		percent of area					
Crowsnest	871	73.2	26.8	64.8	25.8	9.4	-
Bow	2,117	93.9	6.1	41.5	44.9	13.1	0.5
Clearwater-Rocky	3,828	61.7	38.3	38.9	26.6	32.7	1.8
Edson	5,143	39.2	60.8	37.6	35.5	26.7	0.2
Whitecourt	4,298	37.6	62.4	21.7	18.6	51.0	8.7
Grande Prairie	4,565	33.3	66.7	29.9	17.1	51.4	1.6
Mean East Slopes [4]		48.7	51.3	34.4	26.8	36.2	2.6

1. All land in management units, including productive, potentially productive and non-productive.

2. Growth in mean annual increment, total cubic feet per acre per year, using crop rotations from 100 to 140 years. Growth is assumed to occur on white spruce, black spruce, mixed spruce and pine. Stands over 80 feet tall are considered to have no growth.

3. Canada Land Inventory growth capability classes (in brackets) are based on lodgepole pine on a 100 year crop rotation. Class 3 is the highest rated by the province. Classes 6 and 7 are not considered capable of producing commerial forest in Alberta.

4. Mean weighted by acreage.

Forest in the East Slopes.

Rates of 15 cubic feet per acre per year have been assigned mainly to sub-alpine areas (physiographic provinces 1 and 2) and 25 cubic feet per acre per year to boreal areas (physiographic provinces 3 and 4). There is a general trend toward more productive forest land from south to north. In general terms these rates appear reasonable, perhaps even somewhat conservative, for previously unmanaged forest of the age and condition characteristic of the East Slopes, under the climatic conditions that prevail. However, there is now considerable need for refinement of growth estimates to facilitate more accurate calculations of inventory, allowable cut and financial aspects of timber-growing investments, as the need to compare timber growing to other alternative land uses becomes more critical in the East Slopes.

Table J-1 also summarizes potential growth or productivity rates for forest land, in terms of C.L.I. capability classes[10]. There is a definite trend toward increasing potential forest productivity from south to north in the East Slopes.

Growth capability classes are an expression of all environmental factors affecting tree growth and significant changes in growth could only be achieved through costly investments. They probably represent an upper limit to growth rate in the East Slopes in practical terms, because forestry investments for growth increase are probably not justifiable under current or foreseeable economic conditions for commercial forestry.

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[10] McCormak, R.J. 1972. The Canada Land Inventory - land capability classification for forestry. Dep. Environ., Ottawa., 72 pp.

Fire, and epidemic levels of insects and disease are major current sources of forest depletion in the East Slopes. <u>All three pose difficult land use planning and management problems in terms of prediction, detection and suppression. Prediction is still a most difficult problem and places major limitations on rational planning for forested land.</u> Detection has been considerably improved recently with the advent of remote sensing from aircraft and satellites. Suppression technology is advancing, but in its wake come serious questions of environmental degradation, particularly with respect to synthetic chemical insecticides.

Forest insect and disease conditions are monitored annually by the Forest Insect and Disease Survey[11]. Endemic and epidemic conditions are reported, <u>providing a useful source of information for land use planners and managers</u>.

Fire deserves special consideration because of its historic role in the cycle of forest destruction and renewal in the East Slopes (all major species being adapted to regeneration after fire, particularly lodgepole pine), the increasing threat which fire will pose to all users of forested land as land use intensifies, and because fire expenditures are currently among the highest of any resource protection or management expenditure in the East Slopes. Table J-2 illustrates the prevalence of fire on an area basis, and the relative success of fire control in the East Slopes in the period 1960-69. Fire suppression has high priority in Alberta as a whole, as illustrated by the fact that, for the period

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[11] Survey maintained by the Department of the Environment of Canada.

UNITS IN EAST SLOPES FORESTS

Provincial Forest	Area Burned (acres) 1960-69 [1]	Allowable Burn (acres) 1960-69 [2]	Excess Allowable Over Burned (acres) 1960-69	Total Fire Suppression Costs 1960-69 [4]
Crowsnest	27	7,372	7,345	88,798
Bow	1,080	15,683	14,603	197,734
Clearwater - Rocky	15,368	33,444	18,076	634,850
Edson	33,808	49,926	16,118	1,018,324
Whitecourt [3]	168,948	41,123	(-) 127,825	3,353,395
Grande Prairie	23,704	45,041	21,337	711,025
Total East Slopes	242,935	192,589	50,346	6,004,126
Alberta	1,029,263	760,278	(-) 268,985	16,542,042
Percent [6]	23.6	25.3		36.3

1. Refers to productive, potentially productive and non-productive land.

2. Based on rate of 0.1 percent of Forest area, excluding water, clearings, rock barrens, and Indian Reserves. It is the amount of burn tolerable within the limits of a sustained yield forest management plan.

3. The Whitecourt Forest is an anomaly as fuel and hazard conditions are different than in other Forests of the East Slopes. Average data are distorted by an exceptionally severe 1968 tree season.

4. A large proportion of costs in the East Slopes are pre-suppression costs; not reflected in these figures.

5. Figures from Department of Lands and Forests, Alberta, Annual Reports 1960 - 69 inclusive.

1960-69, 12.7 percent of all expenditures by the Department of Lands and Forests were for fire suppression, compared to 4.9 percent for forest management and silviculture[12].

As land use increases in the future, risks of fire will rise, as will protection costs. Reconsideration of the basis for payment of fire protection costs, perhaps with sharing of costs among all users, may well be necessary in the future.

Daily fire hazard ratings are available for the East Slopes[13] and should be particularly valuable to forest land use planners and managers in the future, as forest land use intensifies.

2c) AGE

The lodgepole pine forests of the East Slopes are even-aged, as are approximately 75 percent of the spruce and fir forests, the remainder being uneven-aged or all-aged. Eighty percent or more are below the age of maturity which is currently set at 140 and 100 years for spruce and lodgepole pine respectively in sub-alpine forests and 100 and 80 years respectively in boreal forests.

Trees are long-lived, and the aging process is seldom clearly evident until the stage of over-maturity and decadence is reached,

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[12] Figures from Alberta Department of Lands and Forests Annual Reports, 1960-69 inclusive.

[13] Anon. 1970. Canadian Fire Weather Index. Dept. Fish. Forest., Can. Forest. Serv., 25 pp.

from age 150 to 400 years for spruce and from age 100 to 150 years for lodgepole pine. Under primitive conditions, wildfire ordinarily removed such stands and expedited their replacement by vigorous young stands, but with increasing control of wildfire in the East Slopes this is becoming much less common.

As trees approach maturity the risk of insect and disease epidemics increases and general decadence from endemic pathogens progresses. An example is the recent bark beetle epidemic in old-growth spruce on the West Castle River drainage in the Crowsnest Forest.

Opportunities to alter species composition, growth rate or distributions to meet specific management objectives decrease with increasing forest age.

At present, approximately 50 percent of East Slope forests are middle-aged or older, and the problem of sustaining forest health on a large scale, through direct expenditure, is one which will face forest land use planners and managers for the first time in the near future.

2d) VALUE

The kind and value of commercial wood products originating within the East Slopes in 1970-71 are shown in Table J-3. Products were over 99 percent coniferous.

The East Slopes produced 59.3 percent of Alberta's forest product revenues in 1970-71. Within the East Slopes, 75.0 percent of the product value originated in the Edson, Whitecourt and Grande Prairie Forests, and this proportion should increase when the pulp-mill at Grande Prairie starts up this year.

Provincial Forest	Products	Volume (Thousands of Cubic Feet)	Value[2] ($)	Per Cent
Crowsnest	sawlogs, roundwood[1], fuelwood	6,890	2,607,830.00	10.5
Bow	sawlogs, roundwood, fuelwood, railroad ties	3,382	1,299,922.00[3]	5.2
Clearwater - Rocky	sawlogs, peelers, roundwood, fuelwood, railroad ties	5,871	2,306,240.00[3]	9.3
Edson	sawlogs, pulpwood, roundwood, fuelwood, railroad ties	26,309	6,183,273.00[3]	24.9
Whitecourt	sawlogs, pulpwood, roundwood, fuelwood, railroad ties	9,494	3,543,175.00	14.3
Grande Prairie	sawlogs, roundwood, fuelwood	23,611	8,863,475.00	35.8
Total East Slopes		75,557	24,803,915.00	100.0
Total Alberta		117,699	41,859,115.00	

1. Roundwood includes poles, posts, and piling.
2. Value used is wholesale f.o.b. mill, obtained using 1970-71 timber production records and unit prices from the 22nd Annual Report. Alberta Department of Lands and Forests and from the Timber Management Branch, Alberta Forest Service, Edmonton. Timber production figures reflect timber audit additions subsequent to the annual report.
3. Figures include small amounts of "other products" deemed to be slabwood.

J3. MANAGEMENT, CONFLICTS AND COMPATIBILITY

The abundance of forested land in the East Slopes in relation to demands for its use resulted in few serious management or conflict problems in the past. Forest Management was primarily a matter of protection. Recognized primary watershed areas were zoned for protection in the Crowsnest, Bow and Clearwater-Rocky Forests in 1947, and commercial forestry did not reach a scale requiring special management plans to designate land suited for timber production until 1956. In forest management and silviculture, emphasis was placed on commercially valuable tree species, as timber harvesting was the main activity requiring forest manipulation. Therefore, our understanding of silvics and silviculture of tree species in the East Slopes is confined mainly to white spruce, Engelmann spruce, alpine fir and lodgepole pine. Silvicultural systems for harvesting and regenerating these species, to commercial forestry standards, were determined in some detail, but there was little need for application under conditions existing in the past.

The determination of silviculture principles to achieve management objectives in wildlife management, watershed management or various recreational objectives, including landscape aesthetics, received little consideration in the past.

The main land use conflict in the past was between forestry and agriculture. Attempts are still being made to resolve this conflict by exclusive zoning.

3a) PRESENT AND FUTURE MANAGEMENT

Forestry in the East Slopes in general is still in an early stage of development, with minimal investments in silviculture and management. Where silviculture is practised it is aimed almost exclusively at regeneration of commercial timber species. Fire protection has high priority. Management of forests for purposes other than commercial timber production is still minimal.

It is noteworthy that commercial forestry with long-term commitments is presently being developed most strongly in the Edson, Whitecourt and Grande Prairie Forests, which makes sense in terms of both available inventory and forest growth potential in the East Slopes. Such development should help to reduce future conflicts with other forest land users, particularly various forms of recreational use, which are developing most strongly from the Clearwater-Rocky Forest southward.

Public attitudes and demands on forested land in the East Slopes are changing dramatically, in parallel with similar trends in adjacent forested areas of the United States. With the realization that forested land is finite, interested groups are now demanding a voice in land use planning. For example, the Alberta Wilderness Association has made a request for approximately 560 square miles of land as a wilderness area within the Bow Provincial Forest[14]. Other users, including campers, fishermen, and hunters, as well as coal, oil and gas producers are increasing their demands on the land.

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[14] Anon. 1972. Elbow-Sheep wilderness - a recreational wilderness for Albertans. Alberta Wilderness Association, Calgary, Alberta., 41 pp.

Concurrent with increasing demands on forested land by users other than commercial forestry, there is a revolution occurring within commercial forestry which is changing land use requirements. This hinges on three major trends.

1. changes in wood harvesting technology, with a trend toward large capital investments in machinery. Mechanization is placing a premium on uniform forests of high volume per acre on relatively level sites.
2. changes in wood processing technology, with a trend away from logs and boards toward processes that take wood fibre and produce the size, shape and appearance of product desired by the consumer.
3. closer examination of investment returns on silviculture and management of land for commercial forest production, particularly as the costs of labor and capital continue to rise.

The result of the above trends is an emphasis on mechanization of all aspects of forestry, including silviculture, with consequent limits on the operability of rough terrain, de-emphasis of traditional silvicultural treatments like thinning and pruning, and emphasis on investments in the most productive land available for growing timber. These trends could well make much of the rugged, low-production sub-alpine forest land of the East Slopes (physiographic provinces 1 and 2) sub-marginal for commercial forestry as has been recently illustrated for such lands in Montana.[15] Future necessary management of forests on such lands would be justified by requirements for watershed, wildlife and

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[15] Anon. 1970. A university view of the Forest Service. Prepared for the Committee on Interior and Insular Affairs, by a select committee of the University of Montana. U. S. Govt. Printing Office. Wash. D.C., 33 pp.

recreation management, presenting new challenges to forest management and silviculture in the East Slopes.

In the future, commercial forestry must, for the first time, compete with other users for a limited supply of forest land, and the conflicts generated will pose major problems for planners and managers.

There may well be two distinct roles for forest management and silviculture in the East Slopes in the future, both of which will entail a multiple or integrated-use approach to forest land:[16]

1. Management and silviculture with commercial timber production as the primary objective, and major concern for harvesting efficiency and mechanization of all phases of the operations, including silviculture.
2. Management and silviculture with goods and services other than wood products as primary objectives, including water, wildlife, and various recreational opportunities. Management investments will be made to meet the objectives of the primary use, and commercial timber may or may not be produced as a by-product.

The future role of commercial timber production in the East Slopes will be affected by a variety of factors, including:

1. Current trends in harvesting mechanization and wood processing technology.
2. The degree to which timber produced from East Slopes forests will be competitive with timber produced elsewhere in Alberta and Canada.

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[16] See Appendix IV for definition of multiple or integrated use.

3. prospects for increasing the productivity of forest land by silvicultural investments and by improved utilization of existing timber.
4. the effect of forest land uses such as watershed, wildlife, and wilderness and other recreational uses, upon commercial timber production.

The effects of mechanization, changing technology and financial analysis may substantially reduce the acreage of forest land currently considered productive and potentially productive.

Prospects for increasing commercial forest production from a fixed or reduced area of forest land in the future include silvicultural investments to increase growth, and improved utilization of existing timber inventories. Silvicultural investments may not be justifiable beyond density and species composition control during the regeneration phase, with possible yield gains in the order of 30 percent. Improved utilization, on the other hand, both through using more of the tree, and using smaller trees than are currently harvested, could raise yields by more than 30 percent in the future without the financial disadvantage of long-term stand treatment investments required for silviculture.

3b) <u>CONFLICT AND RESOLUTION</u>

The impact of other uses of forest land upon commercial timber production in the East Slopes will depend on:

1. the nature of the uses (some are compatible and others conflict with commercial forestry operations).
2. the degree to which they will compete for productive forest land.

<u>This is an area of land use planning where rational decisions are difficult to make</u>, <u>because of the number and complexity of alternatives available</u>, <u>and where</u>, <u>within limits</u>, <u>economic criteria and computer systems can be of great assistance to the planner</u>.

An initial step in planning for forest land use in the East Slopes, which would help reduce conflicts between commercial timber production and other uses of forest land in the future, has been suggested for six Western U.S. National Forests[17]. The procedure is summarized in Figure J-6.

The study showed that 20 percent of the forest land previously considered available and suitable for long-term (sustained) timber production was in fact not suitable, and <u>showed the inadequacy of traditional forest inventories for current land use planning needs</u>. Reductions were a result of more precise considerations of:

1. forest land productivity
2. forest land stability
3. forest distribution (isolated strips and patches of forest)
4. accessibility
5. conflict with other uses

An example of the possible effect of applying such an inventory method in the East Slopes is shown in Table J-4. <u>The result indicates that the acreage of land within management units on the East Slopes which</u>

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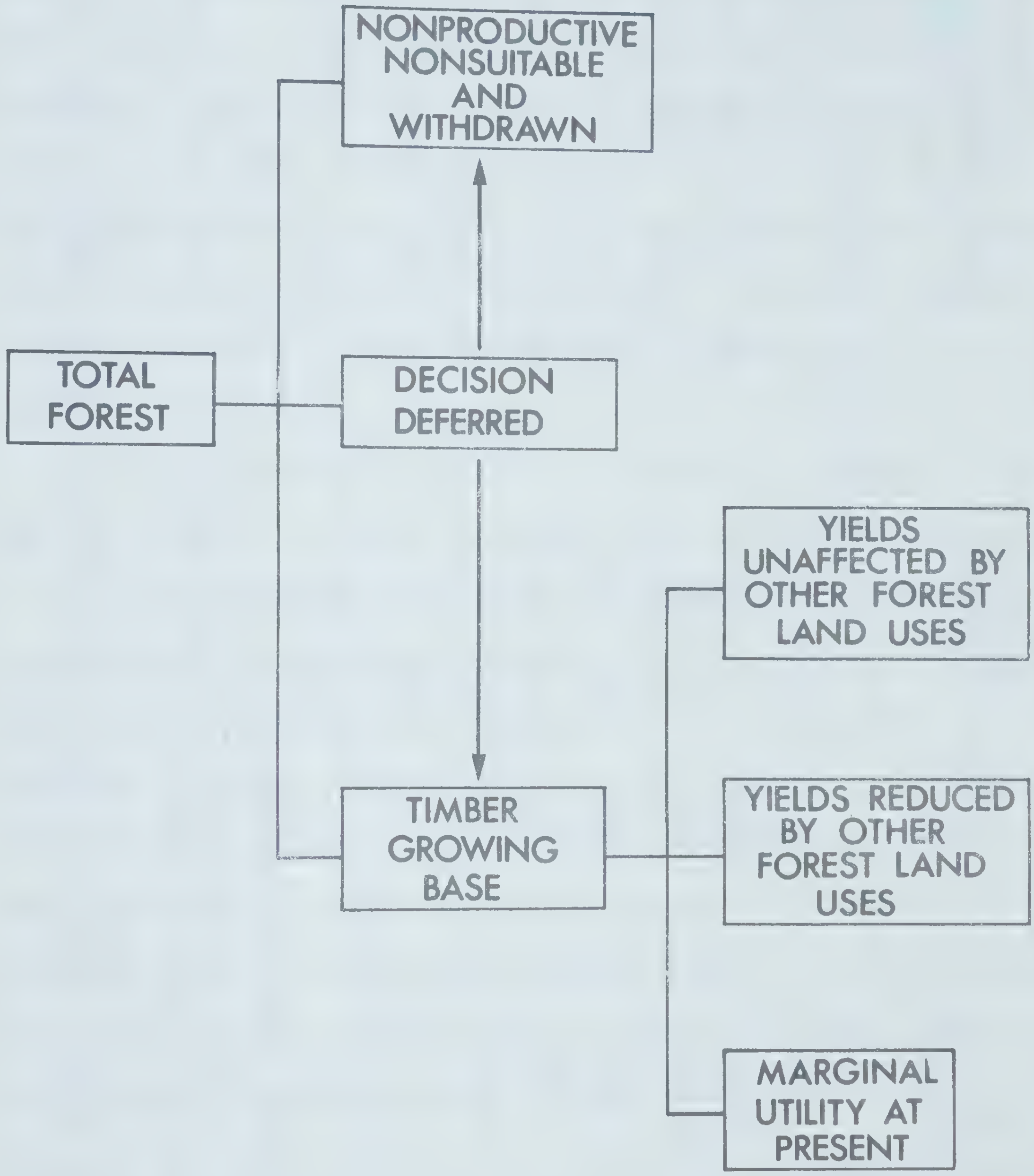
[17] Wikstrom, J.H. and S.B. Hutchison. 1971. Stratification of forest land for timber management planning on the Western National Forests. U.S.D.A., Forest Serv., Res. Paper INT-108., 38 pp.

Figure J-6



A FRAMEWORK FOR IDENTIFYING THE TIMBER GROWING BASE IN THE EAST SLOPES

TABLE J- 4. EFFECT OF RE-EVALUATION OF FOREST LAND PRODUCTIVITY IN THE EAST SLOPES UPON THE TIMBER GROWING BASE.

Provincial Forest	Area[1] (Thousands of Acres)	Current Inventory P[2]	PP	Total	C.L.I. Capability Classes 3[3]	4	5	Total	Difference
		percent of area							
Crowsnest	871	65.6	7.3	72.9	-	9.4	25.8	35.2	(-) 37.7
Bow	2,117	60.9	5.3	66.2	0.5	13.1	44.9	58.5	(-) 7.7
Clearwater-Rocky	3,828	67.9	5.5	73.4	1.8	32.7	26.6	61.1	(-) 12.3
Edson	5,143	73.8	4.7	78.5	0.2	26.7	35.5	62.4	(-) 16.1
Whitecourt	4,298	56.3	11.4	67.7	8.7	51.0	18.6	78.3	10.6
Grande Prairie	4,565	72.0	13.4	85.4	1.6	51.4	17.1	70.1	(-) 15.3
Mean[4]		67.1	8.3	75.4	2.6	36.2	26.8	62.0	(-) 13.4

1. Total area of management unit land in Forests.

2. P = productive area. PP = potentially productive forest land. Data from the Timber Management Branch, Alberta Department of Lands and Forests.

3. Class 3 represents mean annual increment of 80, 4 represents 60, and 5 represents 40 cubic feet per acre per year of growth. Classes 6 and 7 are not included because they are not productive or potentially productive in capability.

4. Mean weighted by acreage.

is currently considered productive or potentially productive for long-term (sustained) forestry purposes would be reduced by an average of 13.4 percent as a result of land productivity considerations alone, with a reduction of 37.7 per cent in the Crowsnest Forest. Other possible sources of reduction in the timber base of East Slopes would be unstable land,[18] forest distribution and accessibility, and conflicts between uses. Forest distribution in isolated patches and stringers would be of particular importance in reducing the timber base in the Bow and Crowsnest Forests.

Table J-5 gives a generalized summary of suitability of East Slopes land for commercial forestry, by physiographic province (see Table C-1).

In the future, the clearcutting method of forest harvesting and regeneration is almost certain to be used on a large scale in commercial forest production in the East Slopes, because some major tree species, particularly lodgepole pine and aspen are well adapted to management of this system, and it favors mechanization. Although there is currently some debate over the effects of size of clearcut upon forest regeneration, especially spruce,[19] there can be no doubt about the adverse effects which large clearcuts have had upon the public in the past[20] particularly in mountainous terrain where cuts are highly visible.

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[18]Rutter, N.W. 1968. A method for predicting soil erosion in the Rocky Mountain Forest Reserve, Alberta. Geol. Survey Can., Paper 67-67;, 32 pp.

[19]Johnson, H.J. *et al.* 1971. Some implications of large-scale clear-cutting in Alberta. A literature review. Dept. Environ., Can. Forest Serv. In/. Rep. NOR-X-G. 114 pp.

[20]Anon. 1971. Forest management in Wyoming. Timber harvest and the environment on the Teton, Bridger, Shoshone and Bighorn National Forests. Wyoming Forest Study Team, U.S.D.A., Forest Service. Wash. D.C., 61 pp.

TABLE J- 5. SUITABILITY OF EAST SLOPES FORESTS FOR COMMERCIAL FORESTRY

Physiog.[1] Province	C.L.I.[2] growth pot.			Climatic suitability			Regen.[3]			Forest[4] Distribution			Forest[5] volume			Slopes			Land Stability			Suitability[6] for Mechanization		
	G	M	P	G	M	P	E	M	D	G	M	P	H	M	L	L	M	H	H	M	L	G	M	P
Mountains (1)			x			x			x			x			x			x		x	x			x
High Foothills (2)		x	x		x	x		x			x			x	x		x	x		x				x
Low Foothills (3)	x	x		x	x		x	x		x			x	x		x	x		x	x		x		
MOST SUITABLE ZONE FOR COMM. FORESTRY																								
Alberta Plains (4)	x	x		x	x		x	x		x			x	x		x			x	x		x		
Valley 5 (5)		x	x		x	x		x	x		x			x	x	x	x		x	x			x	

1 See Figure C-3 and Table C-1 or previous section of brief for description of physiographic provinces.
2 Potential for growth from Canada Land Inventory. G = good (3,4), M = moderate (5), and P = poor (6,7).
3 Ease of regeneration of trees after harvesting. E = easy, M = moderate, D = difficult.
4 Distribution of forest stands refers to stand size and shape. G = good ,and P = poor (isolated stringers and patches).
5 Forest volume refers to range from High - 4500 to 7500 cubic feet per acre to Low - 1000 to 1500 cubic feet per acre.
6 Suitability for mechanization is affected mainly by growth potential, forest volume and steepness of slope.

Both size and timing of clearcuts can be expected to cause conflicts between commercial forest production and other forest-related resource production including wildlife, water, and recreation, in the future.[21]

In summary, harvesting systems and equipment and silvicultural alternatives which will best meet some of the primary objectives of water, wildlife and recreation management in the East Slopes should be considered now in anticipation of needs to manage forests specifically for such purposes in the future. For example, cable and balloon logging systems capable of harvesting timber in mountainous terrain with minimal road construction and soil disturbance on slopes, and with flexibility to harvest in diverse patterns, are already operational (See Appendix V).

The need for adequate planning, management and operational guidelines[22] for all aspects of forest land use in the East Slopes will intensify along with the variety and amount of use. There will be a parallel increase in the need for adequate supervision and enforcement of such guidelines by field staff. For regular forest management, silviculture and harvesting operations alone, this may well require one professional and three or four technical personnel for every 600 to 1,000 square miles of forest[23]. For the six East

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[21]For a detailed discussion of ways in which conflicts can be resolved see: Weddle, R.M. (ed.) 1972. Forest land use and the environment. Montana Forest and Conservation Exp't. Station., School of Forestry, Univ. of Montana, Missoula. 150 pp.

[22]Hough, Stansbury and Associates Ltd. 1973. Design guidelines for forest management. Ontario Ministry of Natural Resources, Queen's Park, Toronto. 181 pp. + appendixes.

[23]From: Criteria outlined by the Ontario Professional Foresters Association in Newsletter No. 49, September, 1971.

Slope Forests this would be a staff of approximately 25 professionals and 100 technicians at the working level.

Changing harvesting and processing technology, and increased emphasis on financial analysis of investments in timber growing in the East Slopes will favor future commercial timber production on the most productive land, on terrain suitable for mechanization. Such land is available primarily in the Edson, Whitecourt and Grande Prairie Forests, east of the mountains. These lands contain the bulk of the coniferous and deciduous forest inventory in the East Slopes and a trend toward long-term commitment to commercial forest production is already established.

Coincident with the above trend, increasing demands for other uses of forest land may be met to a large extent from low production lands and lands unsuitable for mechanization, which describes most of the mountainous area and a large proportion of the East Slopes south of the Edson Forest.

K. ECOLOGICAL IMPACT ASSESSMENT AND CONTROL IN THE EAST SLOPES

K1. PRINCIPLES

Ecological impact assessment is the scientific analysis of the nature and extent to which ecosystems can be altered by given proposed actions. When specific projects or activities are proposed the impact assessment provides for the inclusion of environmental considerations in the design and planning stage. Ecological impact controls can then be recommended, which, if implemented, will prevent or minimize undesirable alterations in various ecosystem components.

Certain basic principles apply to ecological impact and control analysis:

1. the ecosystems must be sufficiently well defined to allow prediction of changes in their structure and function, at least qualitatively;
2. the proposed actions must be described with sufficient accuracy to allow identification of causative factors in ecosystem change;
3. cause and effect relationships between proposed actions and ecosystem changes should be studied to prevent speculation in the assessment. Controls may be based on environmental legislation, scientific studies or experience from analagous situations.

This process of assessment and recommendation of controls need not resolve questions of the economic value of the natural resources affected by proposed actions. Instead, the original structure and function of natural ecosystems is used as the guide in identifying causative factors and potential impact controls. Therefore two further principles are involved:

4. the adaptive capacity of the ecosystem must be considered in relation to the proposed action.
5. if pre-assessment indicates considerable impact but studies are not comprehensive enough, the proposal should either be delayed to allow appropriate analysis, or designed to allow alterations during the operational phase to take into account environmental factors as they are identified.

The following example will demonstrate the application of certain of these principles.

i. In advance of pipeline and highway construction in the Mackenzie Valley, The Department of The Environment of Canada collected data on potential spawning grounds, fish species, feeding habits, and other features of acquatic ecosystems in numerous rivers and streams that would be crossed by the pipeline and road. Environmental consultants also supplied data on the area.
ii. In the fall of 1972, details of the location and design of a highway became available for review and evaluation by DOE. Proposed watercourse crossings, cuts, fills, ditches, borrow pits,

and other factors that could produce changes in these aquatic systems were therefore identified.

iii. Certain cause and effect relationships between these factors and aquatic ecosystems (e.g. soil erosion - sedimentation of watercourses - destruction of spawning beds - reduction in fish populations) are well known scientifically, and control legislation is in the Fisheries Act. Knowledge of these relationships allows recommendations to be made regarding the location, design, and means of construction of the highway, which, if followed, will minimize detrimental effects upon elements of the equatic ecosystems that will be impinged upon.

Actions that are known to cause measurable changes in major elements of ecosystems such as populations of animals or structure or productivity of plant communities, should be met with appropriate recommendations to minimize their undesirable impact. Since many actions affecting ecosystems are already legislated against, the statement and acceptance of recommendations governing these actions should be straightforward.

Decisions to implement recommendations and impact controls are beyond the authority of the original assessor. Impact assessment has a vital role to play in land use and resource allocation, but its value is limited unless it precedes and is integrated with project execution.

K2. SCOPE

Assessment should start with a study of primary impact events and the biological receptors in the immediate vicinity of the proposed actions, i.e., surface and ground water, soil, air, and the plants and animals living in these media; it should then extend outward to downstream, downwind, and downhill locations, and to secondary receptors in the ecosystem. Even though a disturbance is from a specific source such as an effluent, emission, radiation, or physical disruption, the resulting alterations in larger ecosystem components, and the effects upon secondary receptors, may be sufficiently complex to require detailed analysis. Food chain concentration and biogeochemical cycles are examples of the means by which secondary receptors are affected.

Secondary impact events must also be studied. For example, the construction of a highway opens up areas for further development all along its route. In contrast, development along oil pipelines is limited to terminals where wells or refineries are located, but the potential for damage due to spills is great. Control of secondary impacts can usually not be recommended with accuracy, which is one of the limitations of many ecological impact assessments.

Post-development assessments are an important element of impact studies. They provide a check on the accuracy of predicted cause and effect relationships and the effectiveness

of controls implemented. More ecological studies should be done in concert with developmental activities to improve our understanding of cause-effect relationships between proposed actions and ecosystem structure and function.

Impact control recommendations can vary from changes in construction methods, such as avoiding removal of insulating vegetation over permafrost areas, to alterations in design, such as the addition of pollution control equipment and monitoring devices, or relocation of a facility, to rejection of the whole development proposal because of limitations in technology required to prevent major changes in ecosystems.

K3. ENVIRONMENTAL PROTECTION GUIDELINES

Environmental protection guidelines should be formulated for common development projects and activities such as surface mining, highway construction, water impoundments, flood-control and stream channelization, water supply systems, sewage systems, power plants, airports, timber harvest, and solid waste disposal. These guidelines would assist in assessment and control of primary impacts on a project basis and decrease the learning time for each new assessment.

In the East Slopes region, a set of guidelines could be formulated around a given land use or management objective, i.e.

special resource use.[1] Such guidelines would assist both developers and assessors in minimizing environmental impact.

An example of topics covered in guidelines for highway construction is:

1. location in relation to watercourses, critical habitats, potential recreational areas, or sensitive terrain;
2. work camp facilities, layout plans and pollution control facilities;
3. construction techniques for sensitive terrain or habitats;
4. reclamation of borrow pits, access roads, and rights-of-way;
5. timing of construction operations to minimize disturbance of fish and wildlife populations;
6. watercourse crossing methods and structures;
7. temporary stream crossing methods;
8. sources of gravel and other fill materials;
9. erosion control and revegetation methods during and after construction;
10. landscape architectural evaluation and plans; and
11. location of services and secondary facilities.

K4. COMPONENTS OF ECOLOGICAL IMPACT CONTROLS

Water pollution control in a watershed region like the East Slopes must be a basic element of impact control for all projects.

Sewage, industrial effluents, and other sources of water pollution are controlled under various federal and provincial Acts

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[1] See Appendix II of: Nowicki et al, 1972. Foothills resource allocations study. Kananaskis-Spray Drainage District. Phase 1. Preliminary analysis. Forest Land Use Branch, Multiple Use Planning Section, Department of Lands and Forests, Edmonton.

and Regulations. Pertinent federal statutes are:

1. Canada Shipping Act and Garbage Pollution Prevention Regulations,
2. Canada Water Act and Phosphorus Concentration Regulations,
3. Fisheries Act and Pulp and Paper Effluent Regulations,
4. Department of the Environment Act,
5. Migratory Birds Act Regulations,
6. Navigable Waters Protection Act, and
7. Canada Sanitation Regulations.

4a) WATER QUALITY CRITERIA

In addition to these regulations, there are surface water quality criteria available for Alberta and other parts of North America. Excerpts from recommendations of a U.S. National Technical Advisory Committee to the Secretary of the Interior (April, 1968) on water aesthetics and recreation criteria are reproduced here for reference and consideration:

Aesthetics:

1. All surface waters should be capable of supporting life forms of aesthetic value.
2. Surface waters should be free of stubstances attributable to discharges or wastes as follows:
   - i. Materials that will settle to form objectionable deposits.
   - ii. Floating debris, oil, scum, and other matter.
   - iii. Substances producing objectionable color, odor, taste, or turbidity.

iv. Materials, including radionuclides, in concentrations or combinations which are toxic or which produce undesirable physiological responses in human, fish and other animal life and plants.

v. Substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life.

General Recreational Use of Surface Waters:

1. Surface waters, with specific and limited exceptions, should be suitable for human use in recreation activities not involving significant risks of ingestion without reference to official designation of recreation as a water use. For this purpose, in addition to aesthetic criteria, surface waters should be maintained in a condition to minimize potential contamination by utilizing fecal coliform criteria for monitoring.
2. Surface waters, with specific and limited exceptions, should be of such quality as to provide for the enjoyment of recreation activities based upon the utilization of fishes, waterfowl, and other forms of life without reference to official designation of use.
3. Species available for harvest by recreation users should be fit for human consumption.

Enhancement of Recreation Value of Waters Designated for Recreation Uses Other Than Primary Contact Recreation:

1. In waters designated for recreation use other than primary contact recreation, the fecal coliform content, as determined by

either multiple-tube fermentation or mean of 1,000/100 ml. should not equal or exceed 2,000/100 ml. in more than 10% of the samples.

Primary Contact Recreation

1. Criteria for mandatory factors.

   i. Fecal coliform should be used as the indicator organism for evaluating the microbiological suitability of recreation waters.

   ii. In primary contact recreation waters, the pH should be within the range of 6.5 - 8.3 except when due to natural causes and in no case shall be less than 5.0 or more than 9.0. When the pH is less than 6.5 or more than 8.3, discharge of substances which further increases unfavorable total acidity or alkalinity should be limited

2. Criteria for desirable factors.

   i. For primary contact waters, clarity should be such that a Secchi disc is visible at a minimum depth of 4 feet. In "learn to swim" areas, the clarity should be such that a Secchi disc on the bottom is visible.

   ii. In primary contact recreation water, except where caused by natural conditions, maximum water temperature should not exceed 85°F (30°C).

Reference criteria have also been written for water designated for use by fish, other aquatic life, and wildlife. These criteria are useful in assessing ecological impact of developmental activities upon aquatic ecosystems and in stating water pollution control objectives.

4b) AIR QUALITY

Polluted air masses are generally associated with urban centres but can occur wherever local emissions and climatic conditions combine to produce excessive pollutant concentrations and odors. Pulp mills and natural gas processing plants can be sources of air pollution in the foothills.

Environmental Control of Natural Gas Processing Plants was the topic of a Brief to the Alberta Environment Conservation Authority in October, 1972[2], and should be referred to for information on Federal strategies of air pollution control, effects of sulphur compounds on man and other animals, effects of SO_2 and sulphur dust upon vegetation and soils, of sulphur oxides on materials, air pollution meteorology and environmental quality objectives for natural gas processing plants.

Canadian Forestry Service researchers[3] have pointed out that current ground level standards for Alberta allow 1.0 ppm. SO_2 for up to one hour during flaring of sour gas, and that this concentration is lethal to several Alberta forest species.

Odors from garbage dumps often attract wildlife, especially bears, and detract from aesthetic values. This nuisance can be avoided by controlled incineration of refuse and sanitary landfill.

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[2] Brief entitled "Environmental control of natural gas processing plants". A Brief Submitted by the Northwest Region of the Department of Environment of Canada, for Public Hearing held by the Alberta Environment Conservation Authority, Edmonton, Alberta. October 19, 1972.

[3] Loman, A.A., R.A. Blauel, and D. Hocking. 1972. Sulfur dioxide and forest vegetation. Environ. Canada, Northern Forest Res. Centre, Edmonton. Inf. Rep. NOR-X-49. 22 pp.

The aesthetic value and recreational potential of clean, fresh mountain air and water are difficult to describe scientifically but are an important part of the East Slopes environment.

K5. RECOMMENDATIONS ON IMPACT ASSESSMENTS AND STATEMENTS

1. There is a need for clarification of ecological impact assessment and control procedures for the East Slopes region.
2. Procedures for impact assessment and the preparation of ecological impact statements should take into account mechanisms being developed or applied in other parts of Canada and the United States.[4]
3. Impact assessments should be undertaken during all stages of project development, i.e. planning, execution, and operation.
4. Impact statements should be prepared by qualified environmental consultants, government agencies, or industries, and reviewed by control agencies or groups not directly involved in the developmental or financial aspects of the proposal.
5. Impact statements should include considerations of all present legislation, guidelines, and criteria that apply to given proposals and the controls required to adhere to them should be stated.
6. Impact studies, statements and agency reviews should all be made public prior to the initiation or expansion of major projects in the East Slopes.

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[4] Rogers, T.T. 1972. Role of the Environmental Protection Agency in the "102 Process". Paper presented at the Rocky Mountain Mineral Law Foundation, Environmental Law Institute seminar Feb. 26/72 Univ. of Denver, Denver, Colorado.

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Climate.

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APPENDIX I

SOME ECONOMIC EVALUATIONS OF SELECTED LAND USES IN SOUTHWESTERN ALBERTA

SOME ECONOMIC EVALUATIONS OF SELECTED LAND USES IN SOUTHWESTERN ALBERTA

The East Slopes of the Rocky Mountains of Alberta are capable of providing a vast array of goods and services over time. Despite this capability, the region can only provide a limited number of uses at any given time, which gives rise to conflicts. Current major land use conflicts in southwestern Alberta (from the Bow River south) are centered on ranching, wildlife and outdoor recreation. The most visible contentions arise between private landowners and hunters, although there is increasing pressure to terminate public grazing leases and permits in favour of outdoor recreation uses.

Economic analyses of land use and conflicts are difficult and costly to do. Some such analyses, which apply to the East Slopes area, are cited below:

Miller, R.J. 1971. Alberta's Hunting and Fishing Resources: An Economic Evaluation. Economics Division, Alberta Department of Agriculture in co-operation with Fish and Wildlife Division, Alberta Department of Lands and Forests, 1971.

___________ 1971. An Economic Evaluation of Alberta's Sport Hunting and Fishing Resources. Unpublished M.Sc. thesis, University of Alberta, Department of Agricultural Economics and Rural Sociology, 1971.

Moncrieff, P.M., and W.E. Phillips, 1972. Economics Status of Cattle Ranching in Southwestern Alberta. Unpublished manuscript under review for publication, Univ. of Alberta, Department of Agricultural Economics and Rural Sociology, 1972.

Moncrieff, P.M., 1972. Alternative Land Uses in Southwestern Alberta: A Study in Natural Resource Economics. Unpublished M.Sc. thesis, Univ. of Alberta, Department of Agricultural Economics and Rural Sociology, 1972.

Pattison, W.S. and W.E. Phillips, 1971. Economic Evaluation of Big Game Hunting: An Alberta Case Study. Canadian Journal of Agricultural Economics, Vol. 19, No. 2 (Oct. 1971) p. 72.

Patterson, W.S. 1972. Demand for Fish and Wildlife Resources in the Foothills Study Area. Resource Economics Branch, Alberta Department of Agriculture, 1972.

Snipe, J.H. 1970. The Ecological and Economic Impact of Water Resource Development in Southern Alberta: The Case of Fish and Wildlife. Unpublished M.Sc. thesis, Univ. of Alberta, Department of Agriculture Economics and Rural Sociology, 1970.

Whiting, Peter G., 1972: An Economic Evaluation of Recreation in Alberta Provincial Parks in the South Saskatchewan River Basin. Unpublished M.Sc. thesis, Univ. of Alberta, Department of Agricultural Economics and Rural Sociology, 1972.

APPENDIX II

CANADA LAND INVENTORY LAND

CAPABILITY DISTRIBUTION FOR

THE EAST SLOPES

AND CLIMATIC DATA

FOR THE AREA

TABLE 1

CANADA LAND INVENTORY LAND CAPABILITY DISTRIBUTION BY PROVINCIAL FOREST AS COMPILED FROM 1: 250,000 C.L.I. MAPS

CROWSNEST FOREST

Physiographic Provinces	Agriculture Est. Area			Forestry Est. Area			Recreation Est. Area			Ungulates Est. Area			Waterfowl Est. Area		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1. Mountain										1W	13	2			
	5	2	1	4	21	4	1	2	<1	1	29	6	7	526	100
	6	54	10	5	69	13	2	9	2	2W	51	10			
	7	470	89	6&7	436	83	3	5	1	2	152	29			
		526			526		4	70	13	3W	4	1			
							5	258	49	3	112	21			
							6	182	34	4	75	14			
								526		5	90	17			
											526				
2. High Foothills										1W	33	6			
	5	79	13	4	75	13	2	7	1	1	5	1	6&7	598	100
	6	296	50	5	189	32	3	3	<1	2W	79	13			
	7	223	37	6&7	334	55	4	270	45	2	65	11			
		598			598		5	277	46	3W	74	12			
							6	41	7	3	86	14			
								598		4	72	12			
										5	184	31			
											598				
3. Low Foothills	3	2	1	4	28	15	3	3	1	1W	30	16	6&7	191	100
	5	82	43	5	72	38	4	159	84	2W	11	6			
	6	98	51	6&7	91	47	5	26	14	3W	83	44			
	7	9	5		191		6	3	1	3	41	21			
		191						191		4	8	4			
										5	18	9			
											191				
4. Alberta Plains															
5. Valleys	5	25	48	4	4	8	3	3	5	2W	2	4	6&7	51	100
	6	20	40	5	22	43	4	38	76	3W	4	6			
	7	6	12	6&7	25	49	5	6	11	3	33	66			
		51			51		6	4	7	4	-	-			
								51		5	12	24			
											51				

(1) C.L.I. Class.

(2) Estimated area - square miles.

(3) Per cent of physiographic province.

TABLE 1 (continued)

BOW RIVER FOREST

Physiographic Provinces	Agriculture Est. Area			Forestry Est. Area			Recreation Est. Area			Ungulates Est. Area			Waterfowl Est. Area		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1. Mountain	5	7	<1	4	47	3	1	3}	1	1W	55	4	6&7	1339	100
	6	30	2	5	190	14	2	12}		2W	213	16			
	7	1302	97	6&7	1102	83	3	20	1	2	198	15			
		1339			1339		4	141	11	3W	123	9			
							5	574	43	3	511	38			
							6	589	44	4	120	9			
								1339		5	119	9			
											1339				
2. High Foothills				3	2	-									
	5	57	5	4	96	9	2	13	1	1W	79	7	6&7	1095	100
	6	381	35	5	630	58	3	21	2	2W	63	6			
	7	657	60	6&7	367	33	4	378	35	2	34	3			
		1095			1095		5	671	61	3W	80	7			
							6	12	1	3	237	22			
								1095		4	391	36			
										5	211	19			
											1095				
3. Low Foothills	5	343	34	3	16	2	3	3	< 1	1W	8	1	4	1	<1
	6	315	31	4	212	21	4	340	34	2W	79	8	5	12	1
	7	348	35	5	599	60	5	662	65	3W	15	2	6&7	993	98
		1006		6&7	179	17	6	1	-	3	134	13		1006	
					1006			1006		4	622	62			
										5	148	14			
											1006				
4. Alberta Plains	5	84	68	4	79	64	3	2	1	2W	5	4	4	3	3
	6	28	23	5	30	24	4	22	18	2	22	17	5	39	32
	7&0	12	9	6&7	15	12	5	84	68	3	49	40	6&7	82	65
		124			124		6	16	13	4	11	9		124	
								124		5	37	30			
											124				
5. Valleys	5	14	14	5	37	37	4	88	88	3W	24	24	5	6	6
	6	69	69	6&7	63	63	5	12	12	3	23	23	7	94	94
	7	17	17		100			100		4	29	29		100	
		100								5	24	24			
											100				

TABLE 1 (continued)

CLEARWATER-ROCKY FOREST

Physiographic Provinces	Agriculture Est. Area (1)	(2)	(3)	Forestry Est. Area (1)	(2)	(3)	Recreation Est. Area (1)	(2)	(3)	Ungulates Est. Area (1)	(2)	(3)	Waterfowl Est. Area (1)	(2)	(3)
1. Mountains										1W	48	3			
	5	6	<1	4	12	1	1	4	<1	2W	153	11	7	1456	100
	6	19	1	5	189	13	2	20	1	2	150	10			
	7	1431	98	6&7	1255	86	3	14	1	3W	216	15			
		1456			1456		4	187	13	3	209	14			
							5	295	20	4	158	11			
							6	936	64	5	152	10			
								1456		6	370	26			
											1456				
2. High Foothills										1W	74	7			
	5	51	5	4	127	12	2	8	1	2W	77	7	7	1061	100
	6	128	12	5	628	59	3	3	<1	2	23	2			
	7	882	83	6&7	306	29	4	281	26	3W	118	11			
		1061			1061		5	729	68	3	181	17			
							6	40	4	4	110	10			
								1061		5	474	45			
										6	4	1			
											1061				
3. Low Foothills	5	619	48	3	2	<1	3	12	1	1W	44	3	5	9	1
	6	160	12	4	643	49	4	212	16	2W	47	4	6&7	1280	99
	7	510	40	5	421	33	5	1056	82	2	20	2		1289	
		1289		6&7	223	17	6	9	1	3W	66	5			
					1289			1289		3	194	15			
										4	543	42			
										5	375	29			
											1289				
4. Alberta Plains										1W	14	1			
	3	5	<1	3	123	4	4	141	5	2W	136	5	4	1	<1
	4	101	4	4	1440	51	5	2281	81	2	100	4	5	98	3
	5	1649	58	5	389	14	6	385	14	3W	177	6	6&7	2708	96
	6	340	12	6&7	855	31		2807		3	1159	40		2807	
	7&0	712	25		2807					4	1017	37			
		2807								5	204	7			
											2807				
5. Valleys	6	42	19	4	12	5	3	3	1	1W	96	43	5	3	1
	7	180	81	5	188	85	4	182	82	2W	21	9	7	219	99
		222		6&7	22	10	5	35	16	2	3	1		222	
					222		6	2	1	3W	9	4			
								222		3	44	20			
										4	23	11			
										5	26	12			
											222				

TABLE 1 (continued)

EDSON FOREST

Physiographic Provinces	Agriculture Est. Area (1)	(2)	(3)	Forestry Est. Area (1)	(2)	(3)	Recreation Est. Area (1)	(2)	(3)	Ungulates Est. Area (1)	(2)	(3)	Waterfowl Est. Area (1)	(2)	(3)
1. Mountains	7&0	1330	100	5	28	2	2	2	<1	1W	4	<1	6&7	1330	100
				6&&	1302	98	3	7	1	2W	181	14			
					1330		4	30	2	3W	110	8			
							5	98	7	3	244	18			
							6	1193	89	4	438	33			
								1330		5	210	16			
										6	143	10			
											1330				
2. High Foothills	5	8	1	4	65	5	2	1	-	1W	2	<1	6&7	1373	100
	6	44	3	5	590	43	3	20	1	2W	118	8			
	7&0	1321	96	6&7	718	52	4	227	17	3W	190	14			
		1373			1373		5	632	46	3	195	14			
							6	493	36	4	504	36			
								1373		5	355	26			
										6	9	1			
											1373				
3. Low Foothills	5	771	25	3	10	<1	3	5	<1	1W	6	1	5	20	1
	6	270	9	4	1029	34	4	535	18	2W	100	3	6&7	3007	99
	7&0	1986	66	5	1665	55	5	2240	73	2	2	-		3027	
		3027		6&7	323	10	6	247	8	3W	255	8			
					3027			3027		3	414	14			
										4	1296	43			
										5	954	31			
											3027				
4. Alberta Plains	4	41	1	3	8	<1	3	4	<1	1W	5	<1	4	26	1
	5	1942	46	4	1500	36	4	318	7	2W	167	4	5	197	5
	6	521	13	5	1232	29	5	3142	75	2	72	2	6&7	3966	94
	7&0	1685	40	6&7	1449	34	6	725	17	3W	572	13		4189	
		4189			4189			4189		3	1009	24			
										4	1164	28			
										5	1200	28			
											4189				
5. Valleys	5	50	21	4	118	50	4	63	27	3W	124	52	5	5	2
	6	122	52	5	94	40	5	173	73	4	112	48	6&7	231	98
	7&0	64	27	6&7	24	10		236			236			236	
		236			236										

TABLE 1 (continued)

GRANDE PRAIRIE FOREST

Physiographic Provinces	Agriculture Est. Area			Forestry Est. Area			Recreation Est. Area			Ungulated Est. Area			Waterfowl Est. Area		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1. Mountains	7	148	100	6&7	148	100	5	33	22	2W	22	15	6&7	148	100
							6	115	78	3W	29	19			
								148		3	4	3			
										4	33	23			
										5	57	38			
										6	3	2			
											148				
2. High Foothills	7	318	100	4	5	1	4	6	2	2W	31	10	6&7	318	100
				5	96	31	5	225	71	3W	27	8			
				6&7	217	68	6	87	27	3	105	33			
					318			318		4	95	30			
										5	58	18			
										6	2	1			
											318				
3. Low Foothills	5	16	2	4	34	4	2	1	<1	2W	81	9	6&7	892	100
	7	876	98	5	736	82	4	36	4	3W	81	9			
		892		6&7	122	14	5	797	89	3	397	45			
					892		6	58	6	4	293	33			
								892		5	40	4			
											892				
4. Alberta Plains	3	396	9	3	89	2	3	6	<1	1W	158	3	4	4	<1
	4	1510	33	4	2830	62	4	173	4	2W	474	10	5	27	1
	5	365	8	5	151	3	5	4073	87	2	241	5	6&7	4577	98
	6	257	5	6&7	1538	33	6	356	8	3W	283	6		4608	
	7&0	2080	45		4608			4608		3	1635	36			
		4608								4	1592	35			
										5	225	5			
											4608				
5. Valleys															

TABLE 1 (continued)

WHITECOURT FOREST

Physiographic Provinces	Agriculture Est. Area (1)	(2)	(3)	Forestry Est. Area (1)	(2)	(3)	Recreation Est. Area (1)	(2)	(3)	Ungulates Est. Area (1)	(2)	(3)	Waterfowl Est. Area (1)	(2)	(3)
1. Mountains															
2. High Foothills															
3. Low Foothills	5	38	84	4	3	7	5	25	54	4	45	100	6	45	100
	6	-	-	5	28	62	6	20	46						
	7&0	7	16	6&7	14	31		45							
		45			45										
4. Alberta Plains	2	1	-	3	338	8	3	1	-	1W	46	1	3	6	-
	3	10	<1	4	1974	46	4	182	4	2W	50	1	4	17	1
	4	1112	26	5	694	16	5	3241	75	2	137	3	5	71	2
	5	2188	50	6&7	1314	30	6	896	21	3W	291	7	6&7	4226	97
	6	245	6		4320			4320		3	702	16		4320	
	7&0	764	17							4	2165	50			
		4320								5	929	22			
											4320				
5. Valleys															

TABLE 1 (continued)

SLAVE LAKE FOREST

Physiographic Provinces	Agriculture			Forestry			Recreation			Ungulates			Waterfowl		
	Est. Area			Est. Area			Est. Area			Est. Area			Est. Area		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
1. Mountains															
2. High Foothills															
3. Low Foothills															
4. Alberta Plains	3	5	1	3	26	4	4	49	7	1W	14	2	5	1	-
	4	220	33	4	376	56	5	509	76	2W	6	1	6&7	672	100
	5	349	52	5	45	7	6	115	17	3W	43	6		673	
	6	27	4	6&7	226	33		673		3	269	40			
	7&0	72	10		673					4	341	51			
		673									673				
5. Valleys															

TABLE 2

CLIMATIC DATA FOR THE EAST SLOPES[1]

CLIMATIC STATION	ELEVATION (feet A.S.L.)	TEMPERATURE (°F) MEAN ANNUAL	PRECIPITATION (in.) MEAN ANNUAL	GROWING-SEASON DAYS ABOVE 42°F	FROST FREE DAYS	YEAR OF RECORD	PHYSIOGRAPHIC PROVINCE*
Waterton Park - H.Q.	4200	41	42.7	-	118	16	3
Pincher Creek	3758	40	20.7	177	98	30	4
Beaver Mines	4218	39	24.3	-	64	30	3
Coleman	4312	-	20.3	-	-	30	5
Pekisko	4721	36	25.1	-	-	30	3
Kananaskis	4560	37	25.2	159	55	21	3
Exshaw	4260	39	20.5	-	-	15	5
Banff	4583	36	18.7	88	64	29	5
Lake Louise	5032	32	30.8	138	13	30	2
Nordegg	4300	34	22.2	-	40	25	3
Rocky Mountain House	3330	37	21.4	150	73	23	4
Coalspur	3850	30	23.7	-	-	8	4
Entrance	3300	37	19.9	-	51	30	5
Jasper	3480	37	16.4	84	77	25	5
Edson	3027	35	20.8	161	63	30	4
Muskeg R.S	4025	32	23.0	130	-	>10	3
Grande Prairie	2190	35	17.3	86	108	10	4

* See Figure C3.

[1] MacKay, G.A., G.E. Curry and A.S. Mann. 1963. Climatic records for the Saskatchewan River headwaters. P.F.R.A. Engineering Branch, C.D.A.

APPENDIX III

SOME IMPLICATIONS OF WIND, TEMPERATURE, HUMIDITY AND PRECIPITATION FOR LAND USE PLANNING

Parameter and Mode of Expression	Planning Importance: Recreational	Planning Importance: Urban-Industrial
	Categories: (a) great (b) moderate (c) lesser	
1) Wind		
- distribution frequency by direction for various speed categories	great, basic data for locating towns, industry, recreation grounds	great
- length of durations, wind expecially, from critical directions under stable conditions	lesser, except under chinook conditions	great, forms basis for judging pollutant accumulation and transport zones
- distribution frequencies by direction during periods of snowfall	moderate	great, provides data regarding ultimate snow cover distribution
- extreme values for given probabilities	great	great, basic for building design
- persistance of light winds	great, shows periods when surface based inversions are likely to form or where wind chill effects are least	great
- valley circulations, mountains-plains airflows caused by differential heating	great, (often indicated by temperature differences between valleys and interfleuves). Often this requires special investigation for detection. Important for pollutant transport, ventilation, comfort zones.	moderate

Parameter and Mode of Expression	Planning Importance: Recreational	Planning Importance: Urban-Industrial
2) Temperature		
- monthly averages	great	great, reduction of construction costs
- extreme values for given probabilities	great, comfort forecasts	great, size of heating and air conditioning plants
- departures from central location for varying synoptic conditions	great, meso- and micro-scale planning	great, size of heating and air conditioning plants
- inversion strength in first 100m of altitude and spatial variation, expressed as probabilities or frequencies	lesser, (This usually involves a special measurement program. Moreover, no regional radiosonde stations are representative of the foothills environment). Good information for frost-danger or pollution potential.	great
- durations of very cold or very warm conditions	great, planning of activities	moderate

Parameter and Mode of Expression	Planning Importance: Recreational	Planning Importance: Urban-Industrial
3) Humidity		
- monthly averages	lesser	moderate
- diurnal or weekly averages	moderate to great	moderate to great
- extreme values for given probabilities	great	great, may be used in building design
- humidex or effective temperature	great, comfort forecasting	great

(This is a difficult parameter to work with on account of the small absolute amount of water vapour in the atmosphere which is not only difficult to detect with most instruments currently available, but is also variously expressed as a partial pressure, as a weight per volume, as a ratio, etc. It has great importance for human comfort and certain conditions of air pollution, however.)

Parameter and Mode of Expression	Planning Importance: Recreational	Planning Importance: Urban-Industrial
4) Precipitation		
- monthly average of rain and snow	great, gives broad-scale definition of wet and dry zones	great, separates snow-prone areas
- extreme values for given probabilities	great	great, fundamental for bridge, culvert, and sewer design
- snow cover normals and extremes for each month	great, selection of winter sports areas	great, needed for snow-removal estimates; highway planning, general building location and landscaping.
- storm analysis and maximization of precipitation	moderate	great, provides superior design of estimate for design of water-carrying sturctures
- reliability of given amounts of given times (drought)	great, selection of sports areas; forecasts need for supplementary water supply in summer.	great
- rainfall-runoff ratios	great, used in broad-scale planning	moderate - great
- frequency of freezing precipitation	lesser	great, powerline support studies

Parameter and Mode of Expression	Planning Importance Recreational	 Urban-Industrial
4) Precipitation		
Particulate matter and gases, converted to common unit (ppm) and expressed as		
- hourly averages	great	moderate
- hourly extremes for various probabilities	lesser	great, legal requirements for hourly averages to enforce legislation

APPENDIX IV

GLOSSARY OF TECHNICAL

FORESTRY TERMS

APPENDIX IV

GLOSSARY OF TECHNICAL TERMS

AGE CLASS DISTRIBUTION - The local occurrence of age classes of trees or the representation of different age classes in a forest.

ALLOWABLE ANNUAL CUT - The volume of wood that may be removed from a properly managed area each year.

COMMERCIAL FOREST OR TIMBER GROWING BASE - Land that is being or will be used for growing timber crops for industrial use, where management inputs are made for that purpose. The degree to which harvestable wood yields can be realized from the timber-growing base may be affected by forest uses like watershed, wildlife or recreation.

CONIFEROUS - Belong to the order Coniferae, usually evergreen with cones and needle-shaped leaves and producing wood known commercially as "softwood". In Alberta tamarack and alpine larch shed their needles in the winter but are still coniferous.

DECIDUOUS - Trees that shed their leaves each winter. The term is used in Alberta to designate the class of broad-leaved trees known commercially as "hardwoods" and consequently represents the class of trees opposite to coniferous.

FOOT, BOARD - A unit of measurement represented by a board 1 foot long, 1 foot wide and 1 inch thick. Abbreviated to f.b.m. (foot board measure), and board foot measure is based on the measurement before surfacing or other finishing. In practice

the working unit is 1,000 board feet, abbreviated herein to M f.b.m.

FOOT, CUBIC - A cube 12 inches on each side. A cubic foot of wood is considered to contain from about 4 to 10 board feet depending on natural and manufacturing losses. In Alberta a conversion factor of 1 cubic foot equals 5.29 board feet has been used for inventory conversions.

MULTIPLE OR INTEGRATED USE - Any practice of forestry fulfilling two or more objects of management. A term which, when applied to land management, implies management of the resources on or in the land as well as the land area itself, and can include:

a) simultaneous and continuous use of the resources available from a given land unit (integrated in time and space),

b) rotational use of a resource or resource combination on a given land unit (multiple use over time),

c) zoning to achieve a mosaic of individual uses on a given land unit (geographical separation of uses).

Multiple use principles include the following:

a) forest lands are capable of producing a variety of goods and services in various combinations of management. In many cases, uses can be combined to increase the net benefit to society, relative to single use only,

b) a harmonious combination of land uses, with

flexibility for change in the future and without significant impairment of the land, is desirable (in the public interest),

c) meaningful application of multiple use in land management must be based on clear objectives and on <u>valuation</u> of <u>alternatives</u>, stating the purpose of valuation and the point of view of the "evaluator".

NON-PRODUCTIVE FOREST LAND - Land which is incapable of or not likely to produce timber of commercial value. In the Alberta inventory this includes land under water in lakes, rivers, sloughs, etc., muskegs (both open and wooded), cultivated lands, hay and grass meadows, permanent brush areas, barren lands above tree line, areas where trees are stunted due to elevation and rock barrens.

POTENTIALLY PRODUCTIVE FOREST LAND - Land capable of producing commercial forest crops. In the Alberta inventory it includes lands that are presently productive but containing species less than 30 feet in height which could not be positively identified on the photographs at the time of interpretation. It also includes lands that were and could again be commercially productive if seeded, planted or otherwise treated to improve seed germination and survival condition.

PRODUCTIVE FOREST LAND - Land which is presently producing timber crops that are merchantable or will develop into merchantable stands. It includes all forest types on productive soils that are five feet or taller and may be identified on aerial photographs as

to species at the time of photo-interpretation.

ROTATION - The period of years required to establish and grow timber crops to a specified condition of maturity. Several types of rotation are recognized depending on the economic, silvicultural or technical factors involved.

SILVICULTURE - The art of producing and looking after a forest; the application of the knowledge of growth habits and characteristics to the treatment of a forest (silvics). The purpose of silviculture is to create and/or maintain forest vegetation to best suit the objective of the owner.

SILVICULTURAL SYSTEMS - Planned programs of silvicultural treatment throughout the life of a stand including cutting and regeneration as well as intermediate treatments like thinning. The method of regeneration has such a strong influence on the form and treatment of the stand that the name of the system is often taken from the regeneration method (i.e. clear-cutting). Even-aged silvicultural systems include clear-cutting, shelterwood and seed-tree methods of regeneration and the all-aged system is known as the selection method of regeneration.

SITE - An abstract term indicating the combination of all factors that contribute to the growing capacity of an area to produce forests or other vegetation, including the biotic (living), climate and soil conditions of the area.

STAND (Timber) - An aggregation of trees, occupying a specific area and

sufficiently uniform in composition, (species), age arrangements and condition as to be distinguishable from the forest or other growth on adjoining areas.

APPENDIX V

LOGGING SYSTEMS AND ALTERNATIVES IN THE EAST SLOPES

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LOGGING SYSTEMS AND ALTERNATIVES IN THE EAST SLOPES

As our society demands more of the goods and services available from forested land in the East Slopes - including wood products, water, wildlife and a complex of recreational opportunities and aesthetic experiences - there will be an increasing need for forest management, in which logging systems could play a valuable role.

In keeping with the biological characteristics of the East Slopes forests, which are almost universally even-aged, logging systems adapted to even-aged forest management, primarily employing strip and patch clearcutting and shelterwood silvicultural systems, will be of major importance. Such systems are adaptable to timber, water and wildlife production objectives and to the maintenance of the "natural" appearance of much of the forest landscape. However, logging systems adapted to all-aged forest management using single-tree or group selection silvicultural systems could be important for achieving specific watershed management objectives when forest types (such as uneven-aged or all-aged Spruce-Fir) lend themselves to such management. Such systems would also be adaptable to streamside management for aesthetic purpose and to sanitation cutting to control insect and disease development in the forest.

The efficiency of logging systems used should be judged in terms of the goods and services produced through their employment. For example, if commercial wood production is the primary objective then efficiency should be rated in terms of costs per unit of wood product,

and if high quality water from a watershed were the primary objective then costs per unit volume of quality water would be appropriate. Often a logging system can be employed to produce more than one good or service simultaneously, such as wood products, wildlife habitat and increased water yield, thereby improving its efficiency if the value of all products is considered.

LOGGING SYSTEMS

The following are common logging systems which are now being used or may have application in the East Slopes:

1. Conventional (includes tree length and shortwood)
   a) Trees are felled and delimbed by power saw and forwarded by choker-skidders or crawler tractors to a roadside. Tree lengths are cut into prescribed lengths at the roadside by power saw and loaded onto a truck for transportation to the mill.
   b) Trees are felled, delimbed, and cut to prescribed short lengths by power saw at the stump area. Lengths are forwarded to roadside by choker-skidders or crawler tractors and loaded onto trucks.
2. Full Tree

   Trees are felled by power saw or feller-buncher unit and forwarded to roadside. The full tree is processed at the roadside by mechanically delimbing and topping, and can be further transported as tree lengths, or cut into prescribed lengths and then transported.

3. Tree Length

   Trees are felled by power saw or harvesting machine, delimbed and topped, and forwarded in tree length form to roadside. The tree length may be processed at the roadside and transported in prescribed lengths or it may be transported in the tree length form.

4. Shortwood

   Trees are mechanically felled and processed into prescribed lengths at the stump area and the pieces are forwarded to the roadside where they are transported by truck to the mill.

5. High Lead

   A system of cables is used and pre-cut logs or tree lengths are choked and skidded along the ground to a roadside where they are loaded onto a truck for further transport to water or mill.

6. Skyline

   A system of cables is suspended sufficiently high so that logs or tree lengths are choked and carried clear of the ground to the roadside for further transport. Best technique known here is the running skyline. Present spans are 1,000 feet with 2,000 feet spans under development. Balloon-assist spans up to 5,000 feet are also possible.

Systems 1 and 3 are currently in use in East Slopes forests. Examples of limitations of the logging equipment which may be used with these logging systems in East Slope forests are presented in Table 1, and Table 2 outlines the suitability of the equipment for various physiographic regions, management objectives and silvicultural systems

in the East Slopes. The High Lead system is not discussed because it has serious limitations for logging efficiency in East Slope forests, requiring wood volumes of 5,000 cubic feet per acre or greater to justify its use, and is unsuitable for management objectives other than commercial timber production, especially where watershed management is concerned. The use of High Lead logging has been a major cause of conflict between commercial forestry and other land users in other forested areas.

Skyline systems with or without balloons appear to have potential for meeting future forest management objectives for water, wildlife, recreation and aesthetics in the East Slopes. Such systems may even be developed to a degree of efficiency similar to that achieved with mechanized operations on non-mountainous terrain, with careful matching of equipment to operating and environmental conditions.[1]

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[1] A detailed discussion of radio-operated cable systems in mountainous terrain can be found in: Samset, I. 1973. Forest operations in a dynamic production forestry, illustrated by examples from Norway. Background paper for 1973 H.R. MacMillan Lectures, Univ. of B.C. 41 pp.

TABLE 1. LOGGING EQUIPMENT LIMITATIONS

Logging Equipment	Soil Disturbance by Skid Trails and Landings	Roads[1]	Slope (%)[2]		Soil Limitations	Skidding Distance (ft)		Timber Size or Volume Limitations	
			Eff.	Max.		Eff.	Max.	Eff.	Max.
Crawler (D-6+)	20-30% of area, particularly for skid trails	Max.	0-15	65	Rock outcrops, Deep organic	600	1000	Match machine to desired load size.	
Wheeled Skidder (100 hp+)	10-15% of area, particularly for skid trails	Med.	0-15	35	Rock outcrops, Deep organic	800	1500	Match machine to desired load size.	
Koering Feller, Processor, Forwarder	Limited to landing disturbance	Min.	0	20	Deep organic, Poor drainage	800	1500	10"dbh	8"dbh
Cable Systems (Wyssen) (Norweigen)	Limited to landing disturbance	Min.	Relates to felling not skidding. Max. is slope on which a man can safely work.		None	1000	3000	Not dependent on tree size but on load size-load average-6000 lb.	
Balloon (with running skyline)	Limited to landings and "bedding" balloons	Min.	Same as above		None	1000	3000	Not dependent on tree size but on load size-load average-6000 lb.	
Running Skyline (no balloon)	Limited to landing disturbance	Min.	Same as above		None	600	800	Not dependent on tree size but on load size.	

[1] Road requirements vary with topography and with skidding distance capability of machine. In general, the greater the road requirements, the greater the soil disturbance in an area.

[2] Both slope and skidding distance are rated for efficient operation and maximum safe tolerable limit for machine.

TABLE 2. LOGGING EQUIPMENT SUITABILITY

Equipment	Physiographic[1] Region	Logging System	Suitability for Management[2]									Suitability for Silvicultural[3] System			
			Comm.For.			Water			Wildlife			Even-aged			Uneven-aged
												Clearcut		Shelterwood	Selection
			G	M	P	G	M	P	G	M	P	Patch	Strip		
Crawler	3,4,5	conventional (b) full tree tree length	x	x				x	x	x		Yes	Yes	Yes	Yes
Wheeled skidder	3,4,5	"	x	x			x	x	x	x		Yes	Yes	Yes	Yes
Koering feller, processor,forwarder	3,4,5	shortwood	x	x		x	x			x	x	Yes	Yes	No	No
Cable System (Wyssen) (Norweigen)	1,2	skyline		x	x	x			x	x		Yes	Yes	No	Yes
Balloon (with running skyline)	1,2,3	skyline			x	x			x	x		Yes	Yes	Yes	Yes
Running skyline (no balloon)	1,2	skyline			x	x				x		Yes	Yes	No	No

1 See Figure C-4 and Table C-1.

2 Using efficiency in removing wood from the stump to the landing as the general criterion for commercial forestry, under conditions of wood volume and slope prevailing in the relevant physiographic region. The criterion for water management is minimal soil disturbance due to roads, landings and skidding (tree or log removal from forest) operation. Criterion for wildlife is ability to clearcut strips and patches of varying size and shape.

3 No efficiency criterion considered here, just feasibility of adapting to the silvicultural system.